S
622.34
L3SAP
1990

Chen Northern, Inc.

FINAL

SAMPLING AND ANALYSIS PLAN

PART 1: FIELD SAMPLING PLAN
PART 2: QUALITY ASSURANCE PROJECT PLAN

HUGHESVILLE MINING DISTRICT
REMOVAL SITE INVESTIGATION
PRELIMINARY ASSESSMENT

STATE DOCUMENTS COLLECTI

APR 20 2004

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

Consulting Engineers and Scientists

MONTANA STATE LIBRARY
3 0864 1002 2402 4

FINAL

SAMPLING AND ANALYSIS PLAN

PART 1: FIELD SAMPLING PLAN
PART 2: QUALITY ASSURANCE PROJECT PLAN

HUGHESVILLE MINING DISTRICT
REMOVAL SITE INVESTIGATION
PRELIMINARY ASSESSMENT

Digitized by the Internet Archive
in 2014

https://archive.org/details/finalsamplingana1990chen

FINAL

SAMPLING AND ANALYSIS PLAN

PART 1: FIELD SAMPLING PLAN

HUGHESVILLE MINING DISTRICT
GALENA CREEK DRAINAGE BASIN
REMOVAL SITE INVESTIGATION
PRELIMINARY ASSESSMENT

JUDITH BASIN COUNTY, MONTANA

Prepared for:

Montana Department of State Lands
Abandoned Mine Reclamation Bureau
Helena, Montana

Prepared by:

Chen-Northern, Inc.
Helena, Montana

November, 1990

Copy 4 of 7

TABLE OF CONTENTS

1.0 INTRODUCTION 1
  1.1 OBJECTIVE OF THE FIELD SAMPLING PLAN 1
  1.2 SITE BACKGROUND 1
    1.2.1 Location 1
    1.2.2 Regulatory Background 1
  1.3 SITE DESCRIPTION 3
    1.3.1 Study Area 3
    1.3.2 Possible Contamination Sources 3
    1.3.3 General Site Characteristics 5
  1.4 ELEMENTS OF THE FIELD SAMPLING PLAN 6

2.0 SURFACE WATER SAMPLING 8
  2.1 INTRODUCTION 8
    2.1.1 Purpose 8
    2.1.2 Scope of Work 8
    2.1.3 Schedule 8
    2.1.4 Data Quality Objectives 8
  2.2 LOCATIONS AND RATIONALE 9
  2.3 SAMPLE DESIGNATION AND FREQUENCY 12
  2.4 EQUIPMENT AND PROCEDURES 13
    2.4.1 Field Data Collection 13
    2.4.2 Discharge Measurement Procedure 13
    2.4.3 Sampling Procedure 13
    2.4.4 QA/QC Samples 16
    2.4.5 Sample Handling and Shipment 16
  2.5 SAMPLE ANALYSIS 18

3.0 MONITORING WELL INSTALLATION 20

  3.1 INTRODUCTION 20
    3.1.1 Purpose 20
    3.1.2 Scope of Work 20
    3.1.3 Schedule 21
    3.1.4 Data Quality Objectives 21
  3.2 WELL LOCATION AND DESIGNATION 21
    3.2.1 Rationale 21
    3.2.2 Monitoring Well Designation 22
  3.3 DRILLING EQUIPMENT AND WELL INSTALLATION PROCEDURES 22
    3.3.1 Field Data Collection 22
    3.3.2 Monitoring Well Installation Procedures 24
    3.3.3 Monitoring Well Development 24
    3.3.4 Decontamination Procedures 26

4.0 GROUNDWATER SAMPLING 27
4.1 INTRODUCTION 27
4.1.1 Purpose 27
4.1.2 Scope of Work 27
4.1.3 Schedule 27
4.1.4 Data Quality Objectives 28
4.2 GROUNDWATER SAMPLE LOCATIONS 28
4.3 SAMPLE DESIGNATION AND FREQUENCY 28
4.3.1 Designation 28
4.3.2 Frequency 29
4.4 SAMPLING EQUIPMENT AND PROCEDURES 29
4.4.1 Field Data Collection 29
4.4.2 Well Evacuation 31
4.4.3 Sample Collection 31
4.4.4 QA/QC Samples 31
4.5 SAMPLE ANALYSIS 31

5.0 AQUIFER TESTING 33
5.1.1 Purpose 33
5.1.2 Scope of Work 33
5.1.3 Schedule 33
5.1.4 Data Quality Objectives 34
5.2 TEST LOCATIONS 34
5.3 TEST EQUIPMENT AND PROCEDURES 34

6.0 SOILS/MINE WASTE SAMPLING 35
6.1 INTRODUCTION 35
6.1.1 Purpose 35
6.1.2 Scope of Work 35
6.1.3 Schedule 35
6.1.4 Data Quality Objectives 35
6.2 SAMPLING LOCATIONS AND RATIONALE 36
6.3 SAMPLE DESIGNATION 41
6.4 EQUIPMENT AND PROCEDURES 41
6.4.1 Sampling Equipment 41
6.4.2 Decontamination 42
6.4.3 QA/QC Samples 42
6.5 SAMPLE HANDLING AND ANALYSIS 42

7.0 REFERENCES CITED 44

LIST OF APPENDICES

APPENDIX A STANDARD OPERATING PROCEDURES

LIST OF TABLES

Table No.

1. Summary of Field Activities 7
2. Bottles, Preservatives and Shipping Requirements 17
3. Summary of Sample Analysis, Quantities and Types 19
4. Soil/Mine Waste Sample Areas and Quantities 40

LIST OF FIGURES

Figure No.

1. Location and Vicinity Map 2
2. Site Map 4
3. Surface Water Sampling Stations - North Area 10
4. Surface Water Sampling Stations - South Area 11
5. Surface Water Sampling and Measurement Form 14
6. Monitoring Well Completion Log 23
7. Monitoring Well Schematic 25
8. Groundwater Sampling Form 30
9. Location of Soil Sampling Sites - North Area 38
10. Location of Soil Sampling Sites - South Area 39

1.0 INTRODUCTION

1.1 OBJECTIVE OF THE FIELD SAMPLING PLAN

The objective of this field sampling plan (FSP) is to present a detailed description of all investigatory activities that will be performed as part of the preliminary assessment in the Galena Creek drainage. The purpose of the field sampling program associated with the preliminary assessment is to gather environmental data to provide a basis from which subsequent site investigations and removal alternative evaluations can be completed at the project site. In addition, data collected during this field effort will be used to identify operable units within the study area. This plan is a companion document to the preliminary assessment work plan and quality assurance project plan (QAPP).

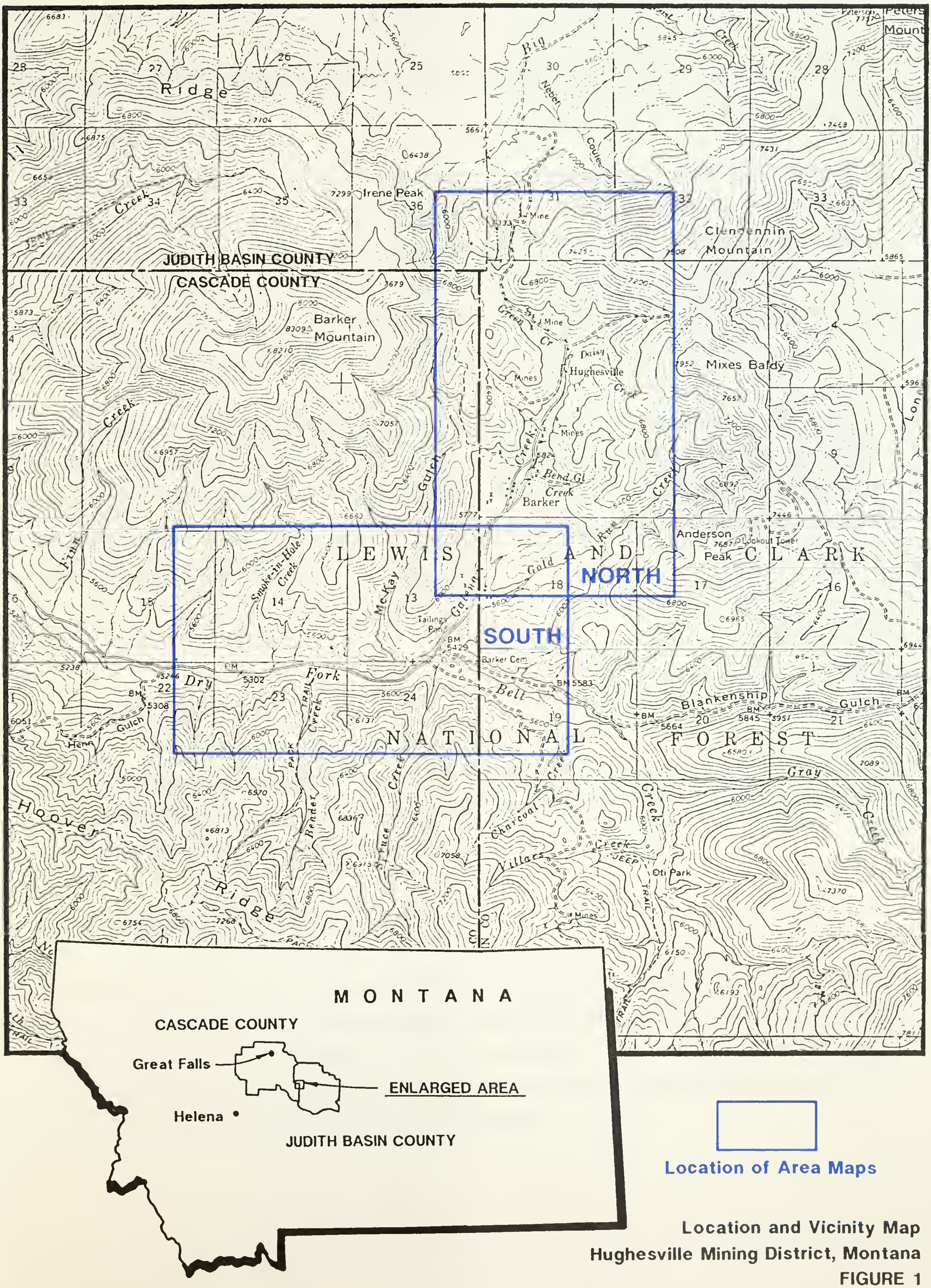
1.2 SITE BACKGROUND

1.2.1 Location

The Hughesville Mining District is located within the Galena Creek drainage of north-central Montana (Figure 1). The study area is located approximately 10 miles east of Monarch, Montana. The site is accessed via U.S. Forest Service Road No. 120 which joins with Montana Highway 89 near Monarch.

1.2.2 Regulatory Background

The Abandoned Mine Reclamation Bureau (AMRB) of the Montana Department of State Lands (DSL) is the lead agency for this preliminary assessment of the Galena Creek drainage. The AMRB receives its appropriations from the Federal Office of Surface Mining (OSM) via a tax levied on the nation's coal producers. Other regulatory entities have an interest in activities to be completed at the site. These include the U.S. Environmental Protection Agency (USEPA), the U.S. Forest Service (USFS), the Montana Department



Location and Vicinity Map
Hughesville Mining District, Montana
FIGURE 1

of Health and Environmental Sciences Solid and Hazardous Waste Bureau (SHWB), and other state agencies.

The Montana Department of Natural Resources and Conservation (DNRC) completed a study in the area during the 1970's in support of their reclamation efforts at the Block P Mine dump. Data collected during this study indicated that Galena Creek water quality is severely impacted by mine wastes in the Hughesville district and acidic adit and shaft discharges. Relatively high concentrations of several metals were measured in both Galena Creek and in point source inputs to the stream.

The AMRB completed a hazardous mine opening inventory in the district during the late 1980's. This inventory provides information on locations of mine waste sources, adits, and shafts. The AMRB is also in the process of completing environmental assessments on certain sites within the Hughesville Mining District in support of construction grant applications through OSM.

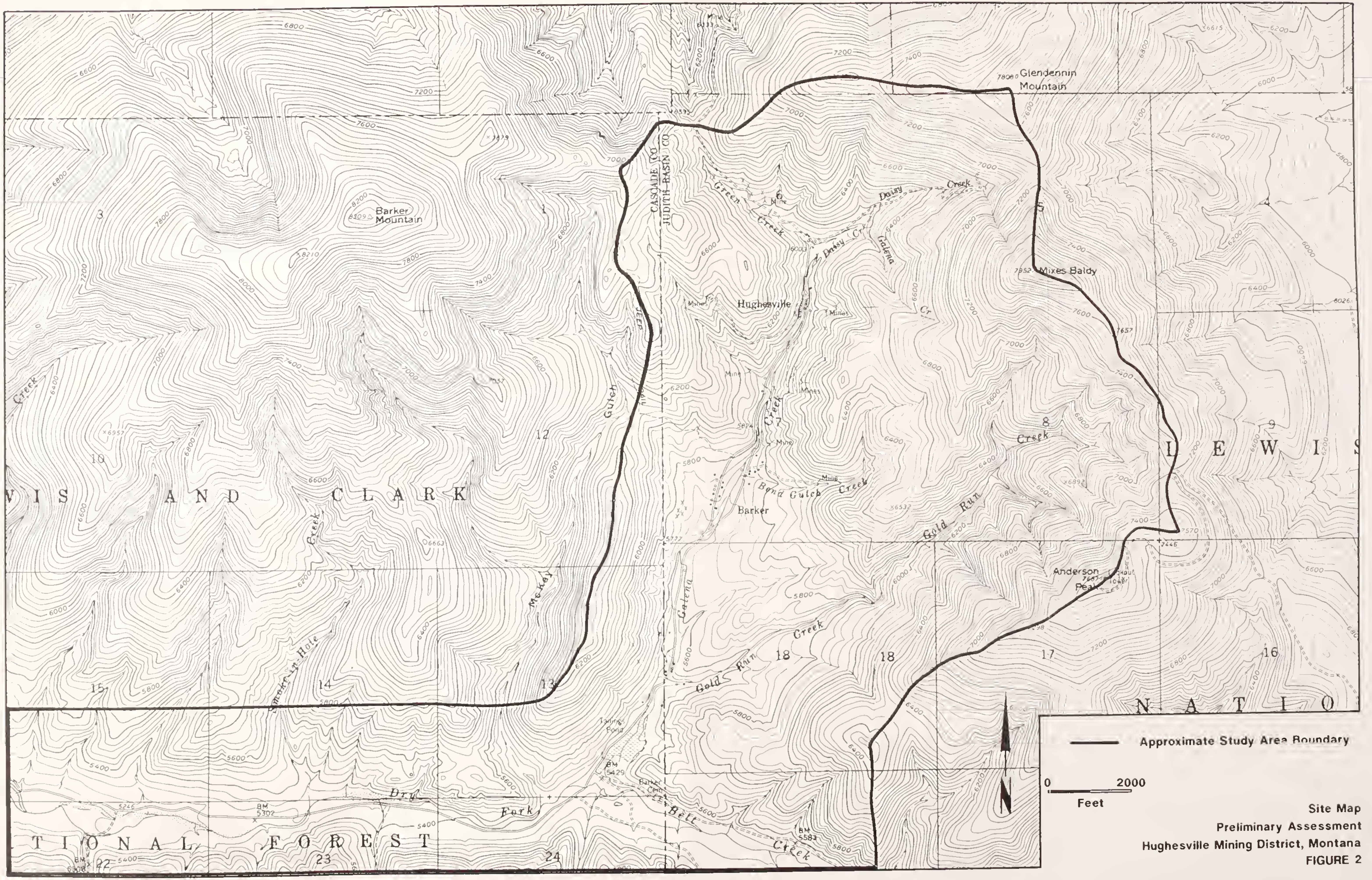
1.3 SITE DESCRIPTION

1.3.1 Study Area

The approximate study area for this preliminary assessment is shown on Figure 2. The area generally includes the entire Galena Creek drainage and a portion of the watershed associated with Dry Fork Belt Creek.

1.3.2 Possible Contamination Sources

Several possible sources of contamination are present within the study area. These sources may include mine waste dumps, streamside tailings, impounded tailings, acid mine discharge, and underground mine workings. The chemical and physical characteristics of these source areas are generally unknown. It is probable, however, that the contaminants of concern at the site are metals.



Site Map
Preliminary Assessment
Hughesville Mining District, Montana
FIGURE 2

1.3.3 General Site Characteristics

Galena Creek is located in a narrow valley bounded on both sides by relatively steep topography. Mine adits and shafts are located both along the valley bottom and along the adjacent hillsides. The historic towns of Barker and Hughesville are located along the valley bottom within the study area. The study area is primarily located on private land which includes both patented and unpatented mining claims. Most residents only reside in the area on a seasonal basis, typically during the summer months.

Galena Creek is a perennial stream which starts at the confluence of Green Creek and Daisy Creek. The stream is apparently sustained by groundwater inflow during low flow and baseflow conditions. Daily flows from August, 1973 to October, 1974 averaged approximately 2 cubic feet per second (cfs) at a station near the mouth of Galena Creek. The stream has been adversely impacted by mine wastes and acid mine discharge throughout most of its length. The creek changes color dramatically in the vicinity of the Block P Mine dump from clear to orange-brown. The stream remains off-colored beyond its confluence with Dry Fork Belt Creek.

Mine waste dumps and tailings are present throughout the study area. This material was derived from historic underground mining in the area and as a waste product from area mills. The largest mine waste dump is associated with the historic Block P Mine located near the head of Galena Creek. Two identified adit and/or shaft discharges in the vicinity of the Block P Mine dump appear to directly impact the quality of water in Galena Creek. Two relatively large tailing impoundments associated with the historic Block P mill are located near the mouth of Galena Creek.

Little is known about the groundwater characteristics of the area. Underground tunnels probably affect groundwater flow in the bedrock systems in the area. Several adits which penetrate the bedrock discharge acid mine water. It appears that a narrow alluvial groundwater system associated with Galena Creek is present throughout the length of the stream. The interrelationships between groundwater and surface water in the district are poorly understood.

1.4 ELEMENTS OF THE FIELD SAMPLING PLAN

This field sampling plan (FSP) provides guidance for all field work in the Galena Creek drainage by describing the sampling and data-gathering methods to be used. For each of the field activities, the FSP contains the following elements:

- Objectives
- Proposed sampling or data collection locations
- Sample or data designation and collection frequency
- Sampling or data collection equipment and procedures
- Sample handling and analyses (if applicable)

Field activities described in this FSP are designed to provide the data necessary to: efficiently plan and conduct comprehensive site investigations and studies of removal alternatives; provide preliminary identification of operable units within the study area; and provide a rational basis to prioritize removal activities within the study area. Table 1 summarizes the field activities presented in this document, the general purpose for each activity, and the ultimate use of the collected data.

TABLE 1
SUMMARY OF FIELD ACTIVITIES
PRELIMINARY ASSESSMENT
Hughesville Mining District, Montana

FIELD ACTIVITY	GENERAL PURPOSE	ULTIMATE DATA USE
Surface Water Sampling	Characterize hydrology and identify contaminant source areas	Identify relative significance of various contaminant source areas Identify operable units
Monitoring Well Installation	Characterize hydrogeology	Provide baseline information Provide access for groundwater sampling
Groundwater Sampling	Characterize hydrogeology	Provide baseline information Evaluate removal alternatives
Aquifer Testing	Characterize hydrogeology	Evaluate removal alternatives
Soil/Mine Waste Sampling	Characterize magnitude of metals contamination Characterize physical properties of material	Identify and prioritize operable units Evaluate removal alternatives

2.0 SURFACE WATER SAMPLING

2.1 INTRODUCTION

2.1.1 Purpose

The objective of the surface water sampling program is to gather data from selected locations in the study area to evaluate the relative impacts of the various contaminant source areas on surface water quality. The program is designed to bracket various known contaminant sources and includes provisions for quantifying impacts from both point and diffuse sources. Data resulting from the surface water sampling program will also be used to evaluate the utility of existing DNRC data obtained during the 1970's.

2.1.2 Scope of Work

The scope of work for surface water sampling includes:

- Collection of equal-discharge integrated and depth-integrated surface water samples from selected locations within the study area.

- Measurement of discharge at each sampling site and selected other sites.

2.1.3 Schedule

Surface water sampling at the site is expected to require three to five days to complete for each sampling event. The schedule for implementation of field work described in this FSP is presented in Section 6.0 of the project work plan.

2.1.4 Data Quality Objectives

The surface water data collected during this investigation will be used along with other environmental data to develop a conceptual model of pathways of contaminant movement

in the study area. These data will be used to identify and evaluate the relative environmental impacts realized from the various contaminant source areas present in the Galena Creek drainage. The more important source areas will be targeted for further detailed characterizations in support of removal alternative evaluations.

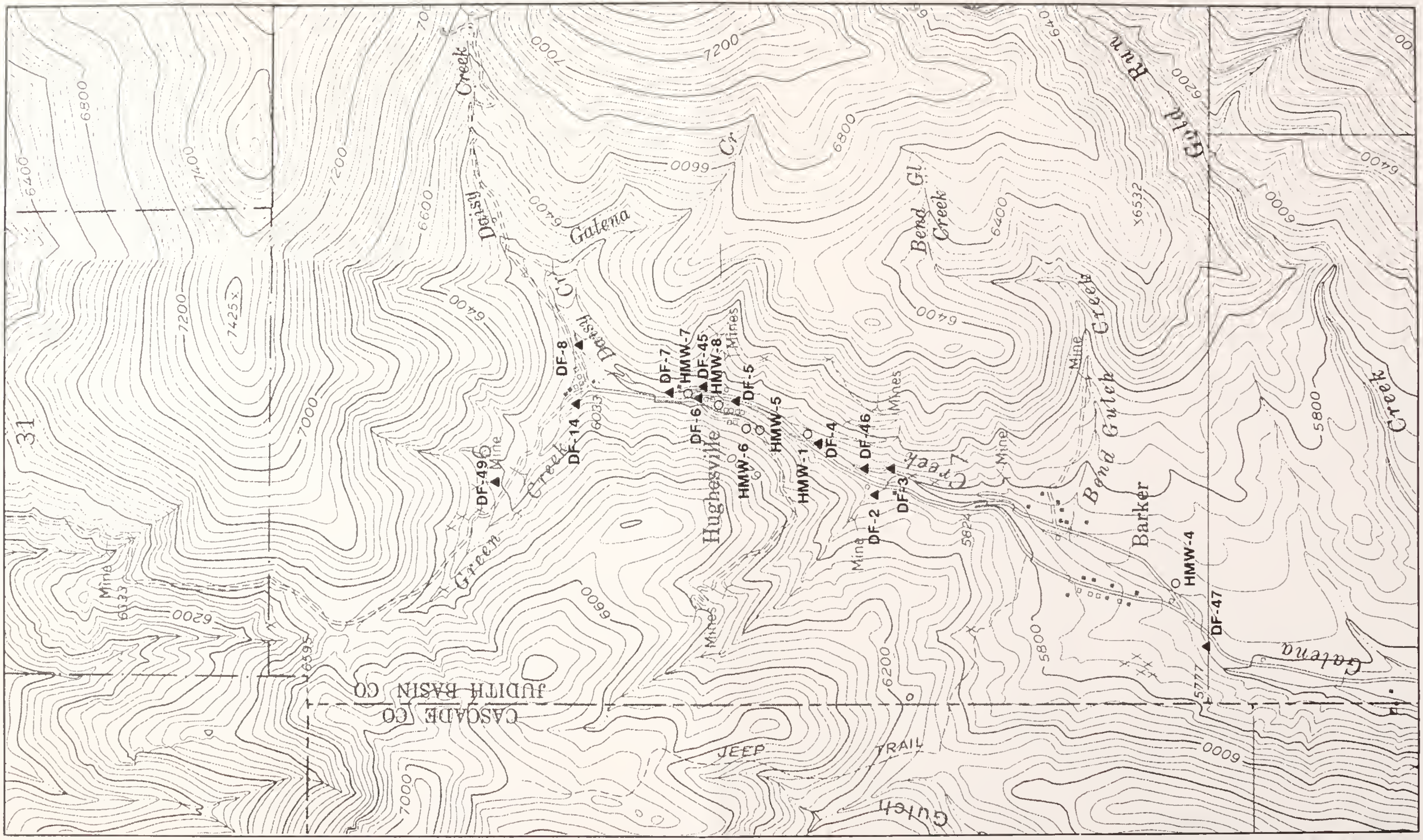
The quality of the surface water data depends largely on the care with which samples are collected. Further, the accuracy of streamflow measurements directly relate to the ability of field crews performing the measurements. For these reasons, field crew members should exercise a high degree of care in both collecting samples and in measuring streamflow.

Based on the evaluation of available surface water data collected by DNRC, it is anticipated that collection and validation of 90% of the planned samples will provide sufficient information to meet project objectives. The goal, however, is to collect all planned samples and validate all resultant data.

Surface water samples will be analyzed for parameters listed in Appendix A of the project QAPP. The samples will be analyzed for general water quality parameters and both dissolved and total metals. The method detection limits and analytical methods used for all constituents analyzed are listed in Appendix A of the QAPP.

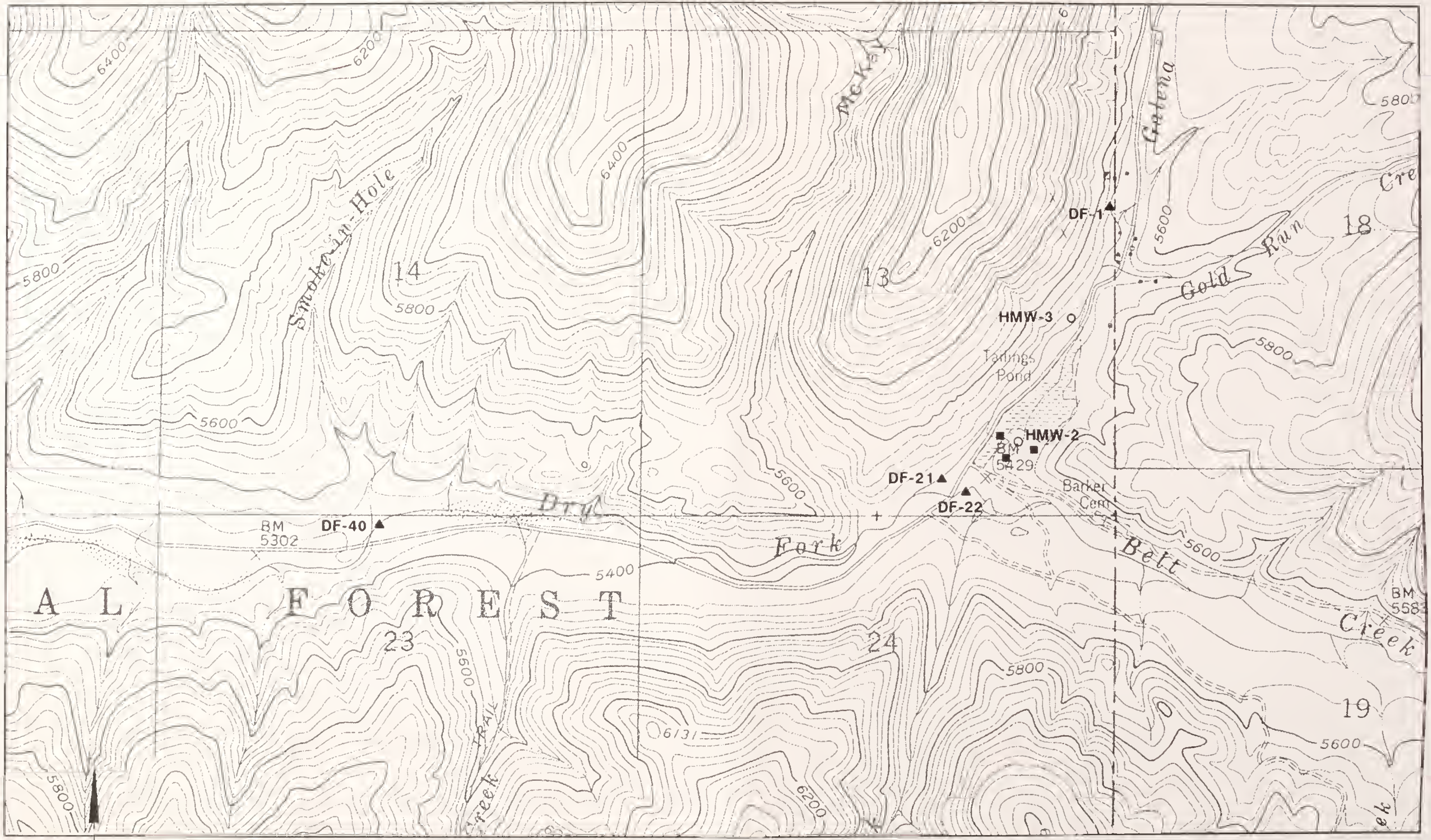
2.2 LOCATIONS AND RATIONALE

Locations of sites to be sampled during this investigation were identified using maps presented in reports prepared by DNRC. It is not critical for field personnel to re-locate these sites precisely but efforts should be made toward establishing sampling sites as closely as possible to those used in the past. Field crews should look for on-site evidence of previous sampling stations (e.g. weirs, stakes, etc.) to establish sampling locations for this investigation. Anticipated locations for surface water sampling in the Galena Creek drainage are shown on Figures 3 and 4.



○ Proposed Monitoring Well
▲ Surface Water Sampling and Gaging Station
■ AMAX Monitoring Well

North Area Monitoring Well Locations and Surface Water Sampling and Gaging Stations
Preliminary Assessment
Hughesville Mining District, Montana
FIGURE 3



N

0 1000
Feet

○ Proposed Monitoring Well
▲ Surface Water Sampling and Gaging Station
■ AMAX Monitoring Well

South Area Monitoring Well Locations and
Surface Water Sampling and Gaging Stations
Preliminary Assessment
Hughesville Mining District, Montana
FIGURE 4

The rationale used to select these sites involved identification of sampling locations which bracket sizable and visible mine waste sources. In addition, certain sampling stations are included to quantify the quality and flow of concentrated discharges entering Galena Creek as either point source input or via drainages.

2.3 SAMPLE DESIGNATION AND FREQUENCY

The surface water sampling stations will be designated using the same numbering system used by the DNRC during their study of the area during the 1970's. New sample sites have been assigned unique sample numbers which DNRC did not sample. Numbers at these sites are consistent with the DNRC numbering sequence. The numbering sequence is illustrated on Figures 3 and 4.

Surface water samples will be collected a minimum of one time during this investigation. Blind duplicate samples will be collected at a minimum of 5% of the stations sampled. Sample containers hosting duplicate samples will be assigned a bogus site number to differentiate it from natural samples. The blind duplicates will be used to assess the precision of the sampling and analytical methods.

Blind cross contamination blanks and blind field standards will also be inserted into the sample train at a minimum of 5% of the stations sampled. Numbering of sample containers hosting these samples will be similar to that described for blind duplicate samples. The cross contamination blank analyses will be used to evaluate field decontamination procedures. Blind field standard analyses will be used to evaluate the precision of laboratory analyses. Further discussion of QA/QC samples is included in the project QAPP.

2.4 EQUIPMENT AND PROCEDURES

2.4.1 Field Data Collection

Field crews will maintain field notebooks throughout the duration of the surface water sampling effort. The field notebooks will be weather-resistant, bound, survey-type books with non-removable pages. Any comments or other notes will be entered directly into the field notebook using permanent, indelible ink. Errors will be lined through and corrected with a new entry. A summary of activities will also be entered into the field book at the end of each field day.

All data generated during the surface water sampling task will be entered on forms designed for this application. Figure 5 is an example of a form which is suitable for this purpose.

2.4.2 Discharge Measurement Procedure

Discharge measurements will be completed in accordance with SOP-1 (Appendix A). Two types of discharge measurements will likely be required for the project. These will include current meter measurements at sites which contain sufficient flow and time-volume measurements at sites which contain minimal flow. All discharge measurement equipment will be decontaminated between sites in accordance with SOP-11 (Appendix A).

2.4.3 Sampling Procedure

Procedures to be used for sampling surface water will vary depending upon site conditions and the quantity of flow at each site. The general method to be used will be an equal-discharge integration (EDI) method combined with depth-integrated sampling. This technique allows representative sampling of a surface water course which may not be completely mixed due to input from line and point sources. This method is described in SOP-3 (Appendix A). Where a sampling site does not contain sufficient flow to allow EDI sampling, grab samples will be collected in accordance with SOP-3 (Appendix A).

FIGURE 5

CHEN-NORTHERN, INC.

Discharge Measurements Notes
and
Sample Notes

Meas. No ____
Comp. by ____
Chkd. by ____

Sta. No. ____________

T ___ N R ___ W, Sec ____, ___ ______________

Date __________, 19 ___ Party ______________

Width ________ Area ________ Vel ________ G.H. ________

Disch. ________ Method ________ No. secs. ______ Susp. ________

G.H. change ______ in ______ hrs. Hor. angle coef. ________

Meter No. ________ Type of meter ________ Date rated ________

Meter ______ ft. above bottom of wt.(highwater)

Spin before meas. ______ after ______.

	GAGE READINGS			WATER QUALITY MEASUREMENTS
Time	Inside	Outside		Samples Collected
				No ____ Yes ____ Time ____
				Method Used
				EDI ____ EWI ____ Other ____

Wading, ice, boat, upstr., downstr., side bridge ______ feet, ab., bl., gage.

Mmt. rated excellent, good, fair, poor.

Flow ______________

Cross section ______________

Control ______________

Gage operating ______________ Weather ______________

Intake cleaned ______ Air ______ °c Water ______ °c @ ______

Record removed ______ Recipient Laboratory Number ______

Cooler Identification Number ______

Remarks ______________

____

____

Temperature Correction Table

Temp	Factor	Temp	Factor	Temp	Factor	Temp	Factor	Temp	Factor	Temp	Factor
-1	1.89	4	1.63	10	1.38	16	1.20	22	1.06	28	0.94
0	1.84	5	1.58	11	1.35	17	1.18	23	1.04	29	0.92
1	1.79	6	1.54	12	1.32	18	1.15	24	1.02	30	0.90
2	1.74	7	1.50	13	1.29	19	1.13	25	1.00	31	0.88
3	1.68	8	1.46	14	1.26	20	1.10	26	0.98	32	0.86
		9	1.42	15	1.23	21	1.08	27	0.96		

Sample Data

Water Temp. (1)	Observed SC(umhos) (2)	Temp. Correction Factor (3)	Cell Factor Above (7)	Sample SC = (2)x(3)x(7) (umhos/cm @ 25°c)

FIGURE 5 continued

River at—

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY		Adjusted for hor. angle or	Area	Discharge
							At point	Mean in vertical			

WATER SAMPLING DATA

Dist. from initial point	Depth at Midpt.	Ave. Q cfs	Appearance of sample

Meter	Serial Number	Date of last calibration
pH		
SC		
Therm.		

pH________s.u. SC________umhos @ 25°c Temp________°c

River at—

Angle coefficient	Dist. from initial point	Width	Depth	Observation depth	Revolutions	Time in seconds	VELOCITY		Adjusted for hor. angle or	Area	Discharge
							At point	Mean in vertical			

Table 2 summarizes the numbers and types of samples to be collected, preservation needs, necessary sample containers, and shipping requirements for the various environmental samples collected during the preliminary assessment.

Field measurements of pH, temperature, and specific conductivity will be completed in accordance with SOPs 6, 7, and 5 (Appendix A) immediately following sample collection. Decontamination of all sampling equipment will be performed in accordance with SOP-11 (Appendix A).

2.4.4 QA/QC Samples

QA/QC samples will be inserted into the sample train at a minimum frequency of 5% of the stations sampled. These samples will be submitted to the laboratory blind and will include duplicate samples, cross-contamination blanks, and blind field standards. At least two sets of these samples will be submitted with every sample lot. Methods and necessary paperwork to complete QA/QC sampling are described in SOP-13 (Appendix A).

Matrix spikes will be prepared in the laboratory for a minimum of 5% of the samples analyzed. Further details regarding laboratory analytical protocol with respect to QA/QC requirements for the project are contained in the project QAPP.

2.4.5 Sample Handling and Shipment

Surface water samples collected during this investigation will be packaged and shipped in accordance with SOP-9 (Appendix A). The minimum holding time for the parameters to be analyzed is 14 days. Because the minimum holding time is relatively long, all samples collected will be shipped in coolers via bus to Chen-Northern's analytical laboratory in Billings immediately following completion of each sampling episode. Advance notice of the shipment date will be given to the laboratory.

TABLE 2
BOTTLES, PRESERVATIVES, AND SHIPPING REQUIREMENTS
Preliminary Assessment
Hughesville Mining District, Montana

SAMPLE TYPE(1)	ANALYSIS	ASSUMED CONCENTRATION	CONTAINER TYPE	PRESERVATION
Soils/Mine Waste	Total Metals	Medium	1 gallon polyethelene bag	None
	Weak Acid Soluble Metals	Low		
	Sulfur Fractionation	Low		
	Texture	N/A		
	XRF	Medium		
Water	Total Metals(2)	Low to Medium	One liter polyethylene bottle; fill to shoulder	HNO_3 to pH < 2
	Dissolved Metals	Low	One liter polyethylene bottle; fill to shoulder	HNO_3 to pH < 2
	Common Ions	Medium	One liter polyethylene bottle; fill to shoulder	Iced to 4° C
	Nitrate + Nitrite	Low to Medium	One liter polyethylene bottle; fill to shoulder	H_2SO_4 to pH < 2

(1) All samples will be shipped via bus or transported by truck following completion of each sampling episode.

(2) Surface water only.

2.5 SAMPLE ANALYSIS

The project QAPP (Appendix A) lists the scheduled analyses for the surface water samples. A summary of the scheduled analysis is listed in Table 3. All samples will be analyzed for metals, major anions and cations, pH, and specific conductance. Analyses of metals will include those for both dissolved and total fractions for the following: aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Appendix A of the project QAPP also lists method detection limits and laboratory methods to be used for the analyses listed above.

TABLE 3
SUMMARY OF SAMPLE ANALYSIS, QUANTITIES AND TYPES
Preliminary Assessment
Hughesville Mining District, Montana

SAMPLE TYPE	ANALYSIS TYPE	SAMPLE QUANTITY			
		NATURAL	DUPS[1]	BFS[2]	XB[3]
Soil/Mine Waste	Total Metals	25	2	2	–
	Weak Acid Soluble	25	2	2	–
	XRF	122	2	2	–
	Sulfur Fractionation	10	1	–	–
	Texture	10	1	–	–
	pH/EC	25	2	–	–
Surface Water	Total Metals	17	2	2	2
	Dissolved Metals	17	2	2	2
	Common Ions	17	2	2	2
	Nutrients	17	2	2	2
	pH/SC	17	2	2	2
Groundwater	Dissolved Metals	12	2	2	2
	Common Ions	12	2	2	2
	Nutrients	12	2	2	2
	pH/SC	12	2	2	2

(1) Dups = Duplicate samples
(2) BFS = Blind Field Standards
(3) XB = Cross-contamination blanks

3.0 MONITORING WELL INSTALLATION

3.1 INTRODUCTION

3.1.1 Purpose

This section describes the locations, depths, and selection rationale for monitoring wells to be installed during the preliminary assessment field investigation. It also describes data quality objectives, drilling equipment, well design and development, and decontamination procedures. The primary objective of the monitoring well installation program is to investigate the groundwater characteristics of the uppermost water-bearing zone in the Galena Creek alluvium at key locations and provide initial data on groundwater characteristics in the Block P Mine dump. In addition, the wells will be used to evaluate which potential sources are contributing to groundwater contamination and to monitor the effects of any future source-control actions which may be implemented at the site.

3.1.2 Scope of Work

To achieve the objectives described above, the scope of work includes:

- Obtaining necessary permission to install wells.
- Drilling, installing, and surveying 7 to 9 monitoring wells with an estimated average depth of 30 to 40 feet.
- Developing all wells until the discharge water is relatively free of turbidity, sand, and drilling fluids.

3.1.3 Schedule

Monitoring well installation is expected to take approximately two weeks. A schedule of preliminary assessment field activities is provided in Section 6.0 of the project work plan.

3.1.4 Data Quality Objectives

Data obtained from the monitoring wells will be used to evaluate the general characteristics of the groundwater within the study area. Lithologic information obtained during drilling will be used during the preliminary assessment to evaluate hydrogeologic conditions with respect to flow paths and contaminant sources.

Types of data to be obtained from the monitoring wells include visual lithologic characterization, groundwater contaminant concentrations, general groundwater quality parameters, hydraulic head, and hydraulic conductivity. It is expected, at certain sites, that determinations of the three dimensional characteristics of groundwater movement may be necessary. This will be accomplished through installation of paired monitoring wells, completed at different vertical intervals.

The selection of 7 to 9 monitoring wells is intended to provide a reasonable distribution of wells throughout the study area. In addition, selected well locations may serve to determine the impact suspected source areas are having on the groundwater system.

3.2 WELL LOCATION AND DESIGNATION

3.2.1 Rationale

The monitoring wells will be located to characterize groundwater conditions both below large mine waste areas, beneath streamside tailing deposits, and within the Block P Mine dump (Figures 3 and 4). The exact monitoring well locations and depths may be adjusted depending on data obtained during drilling activities. The primary focus of the preliminary assessment will be to characterize the upper-most water-bearing zone at each drill site.

After the wells are in-place, groundwater level measurements and sampling will be used to evaluate the potential for off-site impacts.

After drilling and well construction activities are completed, all monitoring wells will be surveyed for elevation relative to temporary staff gages installed on Galena Creek and the Dry Fork Belt Creek. This will provide data with which the influent-effluent characteristics of the stream can be evaluated.

3.2.2 Monitoring Well Designation

Monitoring wells installed during the preliminary assessment will be designated HMW-1 through HMW-7 (see Figures 3 and 4).

3.3 DRILLING EQUIPMENT AND WELL INSTALLATION PROCEDURES

3.3.1 Field Data Collection

Field crews will maintain field notebooks throughout the duration of the monitoring well installation effort. The field notebooks will be weather-resistant, bound, survey-type books with non-removable pages. Any comments or other notes will be entered directly into the field notebook using permanent, indelible ink. Errors will be lined through and corrected with a new entry. A summary of activities will also be entered into the field book at the end of each field day.

All data generated during the monitoring well installation task will be entered on forms designed for this application. Figure 6 is an example of a form which is suitable for this purpose. Important information to be included on this form includes lithologies, water production information, and field parameter data for water encountered during drilling.

Samples of lithologies encountered in each borehole will be collected and bagged. Material samples will be collected from each 5-foot interval or at significant changes in lithology. These samples will be archived for future use.

FIGURE 6

CHEN-NORTHERN, INC.

MONITORING WELL LITHOLOGIC AND COMPLETION LOG

JOB NO.: ____________

PROJECT: ____________________ STATE: ____ COUNTY: ____________ WELL NO.: ____________

LEGAL LOCATION: T____ R____ S____ TRACT______ DESCRIPTIVE LOCATION: ______________________________

DATE STARTED: ______ DATE COMPLETED: ______ DRILLING COMPANY/ DRILLER: __________________ LOGGED BY: ____________

DRILLING METHOD: ______________ BOREHOLE DIAMETER (In): ________ DRILL FLUIDS USED: ______________

TOTAL DEPTH DRILLED (ft): ____ TOTAL DEPTH CASED (ft): ____ INTERVAL PERFORATED OR SCREENED (ft): from: ____ to: ____ DIAMETER AND TYPE OF CASING: ______________

METHOD OF PERFORATION:
___ Open Hole
___ Open Bottom
___ Saw Slotted
___ Factory ____________ (size)
___ OTHER (specify) ____________

DURING WELL CONSTRUCTION WAS/WERE:

	YES	NO
WELL DEVELOPED	___	___
WELL PUMPED	___	___
WATER SAMPLES COLLECTED	___	___
MATERIAL SAMPLES COLLECTED	___	___

ANNULAR COMPLETION CHARACTERISTICS

WELL PROTECTOR: Length ______ Diam. ______

LOCK NO.: ______________

SURFACE SEAL: Type: ________ from: ________ to: ________
BACKFILL: Material: ________ from: ________ to: ________
FILTER PACK: Type: ________ from: ________ to: ________

STATIC WATER LEVEL: ______ MEASURING POINT DATE: ______ DESCRIPTION/ ELEVATION: ______________ MEASURING POINT RELATIVE TO GROUND SURFACE (+/-): ______

REMARKS: ____

INTERVAL (FT) below ground surface	LITHOLOGIC DESCRIPTION	REMARKS

3.3.2 Monitoring Well Installation Procedures

Boreholes which will host the monitoring wells will be drilled from the ground surface to the total depth using air rotary drilling techniques in accordance with SOP-16 (Appendix A). Decontamination of down-hole drilling apparatuses will be completed in accordance with SOP-11 (Appendix A).

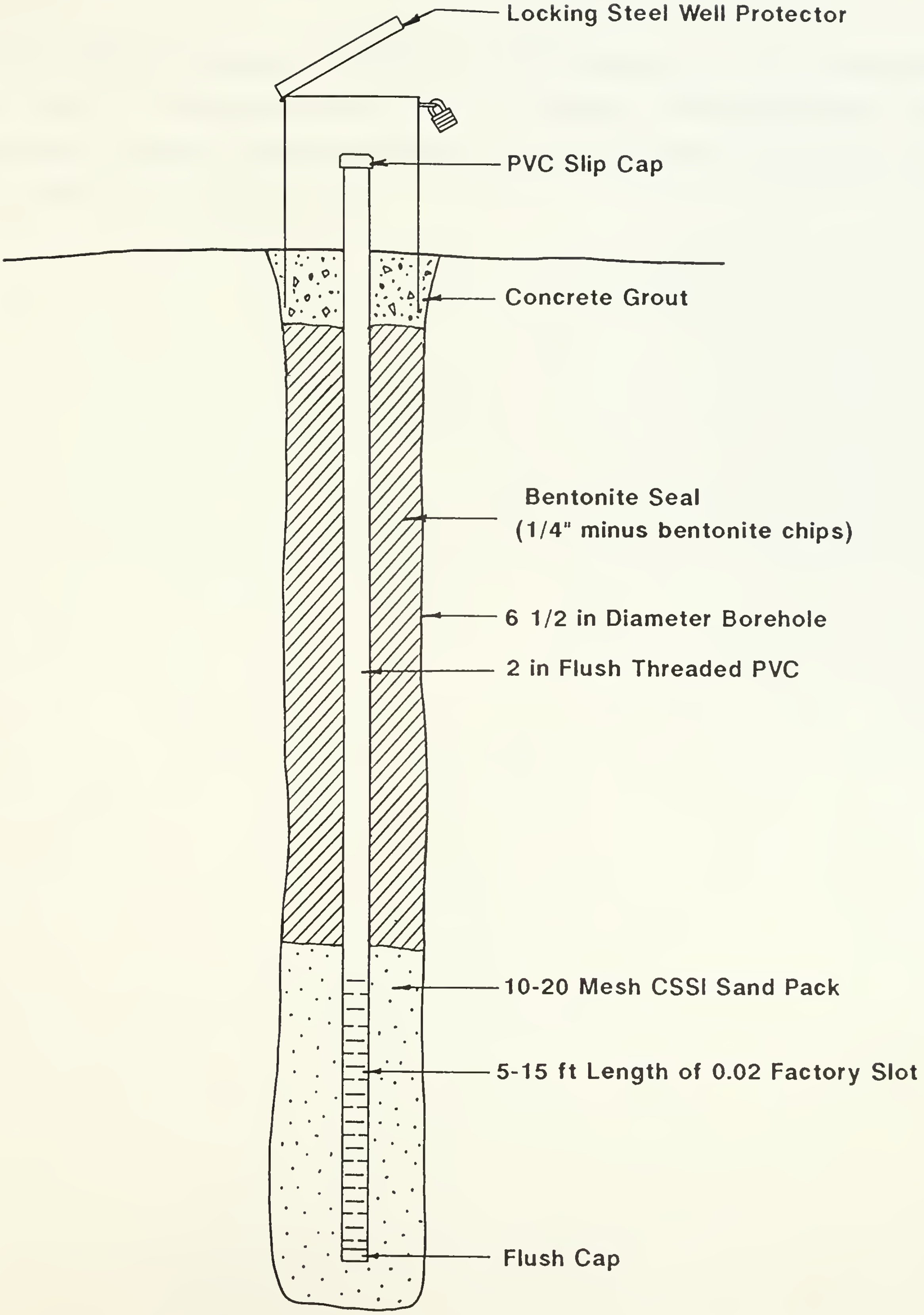
The general monitoring well design is illustrated on Figure 7. Well casing will consist of 2-inch or 4-inch I.D. Schedule 40 PVC. The casing will be flush threaded and PVC casing centralizers will be installed as necessary. The well screen to be used in the installation will be a factory-produced section with a slot size of 0.02 or 0.01 inches.

Clean silica sand will be used to pack the annulus of the screened interval. The sand will be composed of inert non-carbonate material, well rounded and graded to match the aquifer and slot size. The amount of sand to be used in each well will be calculated from the volume of the annulus to be filled. The sand pack will be extended two feet above the top of the well screen.

Natural Wyoming bentonite holeplug chips will be used to fill the annulus from the top of the sand pack to within one foot of the surface. The monitoring wells will be enclosed in a protective steel pipe with a locking cap. The protective surface casing will be set in a concrete pad which slopes away from the well casing.

3.3.3 Monitoring Well Development

The monitoring wells well be developed using a bailer and/or surge block. Development will continue until water being removed is relatively clear and free of sand. The parameters of pH, specific conductivity, and temperature will be monitored during well development. At least three consecutive measurements of these parameters will be within ±5% of each other before well development will be considered complete.


Locking Steel Well Protector
PVC Slip Cap
Concrete Grout
Bentonite Seal
(1/4" minus bentonite chips)
6 1/2 in Diameter Borehole
2 in Flush Threaded PVC
10-20 Mesh CSSI Sand Pack
5-15 ft Length of 0.02 Factory Slot
Flush Cap

Monitoring Well Schematic
Hughesville Mining District, Montana
FIGURE 7

3.3.4 Decontamination Procedures

All down-hole drilling equipment, monitoring well materials, and well development equipment will be decontaminated using a portable decontamination trailer. Decontamination will be completed following completion of each monitoring well in accordance with SOP-11 (Appendix A).

4.0 GROUNDWATER SAMPLING

4.1 INTRODUCTION

4.1.1 Purpose

This section describes the groundwater sampling program planned for the Hughesville District. Data quality objectives are discussed along with the scope of work, sampling locations, equipment, procedures, sample designation and frequency, and sample handling and analysis. The purpose of groundwater sampling is to ascertain the impacts of mining wastes on groundwater quality in the Galena Creek Drainage. The groundwater sampling program is designed to investigate how each of the major contaminant sources impact groundwater quality. Further, the sampling program will provide baseline data upon which the effects of future removal actions can be gaged.

4.1.2 Scope of Work

The scope of work for the groundwater sampling program includes collection of groundwater samples from each of the 7 to 9 monitoring wells described in Section 3.0 of this field sampling plan. In addition, groundwater samples will also be collected from monitoring wells installed by AMAX Exploration, Inc., and any domestic wells in the Hughesville or Barker communities that are accessible. Both the AMAX and domestic wells will be sampled after approval is received from the respective owners. Work included in the groundwater sampling program also includes measurement of static water levels in all wells sampled.

4.1.3 Schedule

Groundwater sampling is expected to take two to three days and will commence when all monitoring wells have been developed. A schedule of preliminary assessment field activities is provided in Section 6.0 of the project work plan.

4.1.4 Data Quality Objectives

Information obtained from analyses of groundwater sampling is required to characterize groundwater chemistry in the Galena Creek Drainage. The primary elements of concern are metals which may be enriched in the local groundwater system through leaching of sulfide metal ores. Enrichment of common ions such as sulfate and magnesium may also be indicative of leaching effects.

The quality of groundwater data depends primarily on proper purging, developing, sampling, and handling procedures to ensure a representative sample of groundwater is obtained. In addition, proper filtering and preservation of samples will ensure data accuracy is achieved.

Groundwater samples will be analyzed for parameters listed in Appendix A of the QAPP. The samples will be analyzed for general water quality parameters and dissolved metals. The method detection limits and analytical methods used for all constituents analyzed are also listed in the project QAPP (Appendix A).

4.2 GROUNDWATER SAMPLE LOCATIONS

Groundwater sampling locations coincide with the seven to nine monitoring wells installed under Section 3.0 of this plan. Anticipated monitoring well locations are shown on Figures 3 and 4. Other sampling locations will include existing domestic wells in the area. Locations of these wells will be determined during field investigations associated with the preliminary assessment.

4.3 SAMPLE DESIGNATION AND FREQUENCY

4.3.1 Designation

Groundwater samples collected from monitoring wells will be identified according to the monitoring well designation (e.g. HMW-1). Blind duplicate samples will be designated with

the number of a non-existent well (e.g. HMW-11). Blind field standards will be designated in a similar manner using a higher series of numbers (e.g. HMW-21). Domestic well samples will be designated with a "HDW" followed by a unique number (e.g. HDW-1). All AMAX monitoring wells will be designated using the same numbering system as used by AMAX.

The date and time of sampling will be recorded on the sample label along with the well designation. Any preservative will also be noted along with the initials of field personnel.

4.3.2 Frequency

Groundwater samples will be collected a minimum of one time during this investigation. Static water level measurements will be obtained prior to collection of groundwater samples. Any additional measurements will be made as deemed necessary by the Project Manager.

4.4 SAMPLING EQUIPMENT AND PROCEDURES

4.4.1 Field Data Collection

Field crews will maintain field notebooks throughout the round of sampling and static water level measurement. The field notebooks will be weather-resistant, bound, survey-type books with non-removable pages. Any comments or other notes will be entered directly into the field notebook using permanent, indelible ink. Errors will be lined through and corrected with a new entry. A summary of activities will also be entered into the field book at the end of each field day.

Prior to sampling, the depths to water will be measured to the nearest 0.01 foot and recorded in the field notebook. Static water levels will be measured with a decontaminated electric well probe or its equivalent. During sampling, all the activities will be recorded on a groundwater sampling log. An example of this log is presented in Figure 8.

FIGURE 8

CHEN-NORTHERN, INC
1610 B Street, Helena, Montana (406) 443-5210

Ground Water Sampling & Measurement Form

Project: ____________ Date/Time: ____________
Sta. No. ______ T ______ R ______, Sec ______, tract ______
Narrative Description ____________
Personnel ____________
Weather ____________
Type of well ______ TD ______ SWL ______
Casing ______ Inside Diameter ______ Log: Y N
Casing Stickup ______ Well Locked: Y N
Aquifer ____________
Measuring Point Description ____________

Meter	Serial No	Calibrated	Meter	Serial No	Calibrated
pH			Eh		
SC			DO		
Thermo			H-Scope		

Depth to Static Water/Continuous Recorder Data

______ ft ______ Hours DSH Reading ______
______ ft ______ Hours DSH Reading ______
______ ft ______ Hours DSH Reading ______
Chart or Chip Removed: Y N Replaced: Y N

Well Evacuation

Bore volume: 1/25 x (TD-SWL) x $(\text{dia})^2$ = ______ gallons
Well Evacuation Method ____________
Remarks ____________

Evacuation Data

SC	pH	DO	Time	Gallons	Rated

STA. NO. ______

Well Sampling Method ____________
Decontamination Code (See page 1 of booklet) A B

Specific Conductance Temperature Correction Table

Temp	Factor	Temp	Factor	Temp	Factor	Temp	Factor
-1	1.89	8	1.46	17	1.18	26	0.98
0	1.84	9	1.42	18	1.15	27	0.96
1	1.79	10	1.38	19	1.13	28	0.94
2	1.74	11	1.35	20	1.10	29	0.92
3	1.68	12	1.32	21	1.08	30	0.90
4	1.63	13	1.29	22	1.06	31	0.88
5	1.58	14	1.26	23	1.04	32	0.86
6	1.54	15	1.23	24	1.02		
7	1.50	16	1.20	25	1.00		

Sample Data

Water Temp. (1)	Observed SC(umhos) (2)	Temp. Correction Factor (3)	Cell Factor Above (7)	Sample SC=(2)x(3)x(7) (umhos/cm @ 25°c)

FIELD DATA

Water Temperature ______ (°C) SC ______ (umhos/cm @ 25°C)
Diss. Oxygen ______ (mg/L) pH ______ (Standard Liters)
S. W. L. ______ (ft) Eh ______ (millivolts)
Water Quality Samples: Y N Chain of Custody: Y N

Bottle	Parameters	Preservative

Lab ____________ Analysis Request Form: Y N
Desc. of Water: Start Finish

4.4.2 Well Evacuation

Well evacuation will be performed in accordance with SOP-18 (Appendix A). The pH, specific conductivity, and temperature of the groundwater will be measured at least three times during well evacuation and recorded in the field notebook. Field parameter measurements will be within ±5% on three consecutive readings before evacuation is considered complete.

4.4.3 Sample Collection

Groundwater samples will be collected using a decontaminated PVC bailer. Caution will be exercised in transferring samples from the bailer to the sample containers so that air entrainment in the sample is minimized. Groundwater samples will be collected in one liter plastic bottles in accordance with specifics contained in Table 2.

4.4.4 QA/QC Samples

QA/QC samples will be inserted into the sample train at a minimum frequency of 5%of the total number of wells sampled. These samples will be submitted to the laboratory blind and will include duplicate samples, cross-contamination blanks, and blind field standards. At least two sets of these samples will be submitted with every sample lot. Matrix spikes will be prepared in the laboratory at a minimum frequency of 5% of the samples analyzed. Methods and necessary paperwork to complete QA/QC sampling are described in SOP-13 (Appendix A).

4.5 SAMPLE ANALYSIS

The scheduled analyses for groundwater samples is contained in the project QAPP (Appendix A). A summary of analysis is contained in Table 3. All samples will be

analyzed for metals, major anions, cations, total dissolved solids, pH, and specific conductance. Analyses of metals will include those for dissolved fractions for the following: aluminum, arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Appendix A of the QAPP lists method detection limits and laboratory methods to be used for the analyses listed above.

5.0 AQUIFER TESTING

5.1 INTRODUCTION

5.1.1 Purpose

The purpose of aquifer testing is to measure the hydraulic characteristics of the groundwater system at locations where monitoring wells have been installed. The testing will consist of performing slug tests in the seven monitoring wells installed during the preliminary assessment. The goal of the tests is to evaluate the hydraulic conductivity of key hydrogeologic units encountered in the study area.

This section describes the aquifer tests to be conducted to measure the hydraulic characteristics of the area's groundwater system. It describes the test locations, equipment, measurements, and data recording techniques.

5.1.2 Scope of Work

The scope of work for the aquifer tests consist of:

- Conducting slug tests in each of the seven new monitoring wells.
- Reducing and analyzing the slug test data.

5.1.3 Schedule

The slug tests will take approximately two to three hours per well. A schedule of field activities for the preliminary assessment is contained in Section 6.0 of the project work plan.

5.1.4 Data Quality Objectives

Aquifer test data obtained from the slug tests will be used to evaluate the hydraulic conductivity of the hydrogeologic units beneath the sites. This parameter will be used to calculate groundwater flow rates and evaluate the potential rate of any contaminant migration.

The performance of slug tests in high conductivity environments may present limitations to the quality and quantity of data collected. The recovery in the wells during a slug test may be so rapid that a proper recovery curve cannot be plotted to calculate hydraulic conductivity. This situation, however, would still provide important and useful information.

5.2 TEST LOCATIONS

Slug tests will be performed in each of the new monitoring wells shown on Figures 3 and 4 and any of the AMAX wells if deemed necessary.

5.3 TEST EQUIPMENT AND PROCEDURES

Field equipment required for slug testing consists of a solid cylindrical slug and a pressure transducer with a data recorder. Slug tests will be performed in accordance with SOP-26 (Appendix A).

Hydraulic pressure and time data from the slug test will be transferred from the data logger directly to a microcomputer. Hydraulic pressure data will be plotted against time to show time-recovery relationships. Slug test data will be evaluated using methods described in Lohman (1972) and Bouwer and Rice (1976).

6.0 SOILS/MINEWASTE SAMPLING

6.1 INTRODUCTION

6.1.1 Purpose

The purpose of the soil/mine waste sampling program is to characterize the magnitude of metals enrichment in native soils and mine and mill wastes. The program is designed to collect a representative number of samples from the various mine waste sources in the study area to determine the relative importance of each with respect to environmental impacts.

6.1.2 Scope of Work

The scope of work for soil/mine waste sampling and analysis generally involves collection of samples from native soils, waste rock dumps, streamside sediments, mine tailings, and mill tailings materials. Samples will be collected from approximately three depth increments from several of the potential contaminant source areas.

6.1.3 Schedule

Soil/mine waste sampling is expected to take from four to six days. Samples will be collected during one sampling event. The schedule for implementation of field work is presented in Section 6.0 of the project work plan.

6.1.4 Data Quality Objectives

Data collected from the soil/mine waste sampling program will be used to evaluate the degree of contamination and relative contribution to environmental degradation associated with each of the major contaminant sources. A minimum number of native soil samples will also be collected to establish baseline metal concentrations in the area.

An X-ray fluorescence (XRF) spectrometer will be used to screen all soil and mine waste material samples for metal concentrations. Metal concentrations determined by XRF analysis will be compared with duplicate samples sent to the laboratory for analytical determination of total metal concentrations. Because the XRF has relatively high detection limits compared to laboratory analyses, the instrument will be used to gain a semi-quantitative measure of metal levels in mine waste materials.

Data quality will primarily be dependent on proper sampling and decontamination procedures. Due to the inherent heterogeneous nature of soil and mine waste materials and given the accuracy and precision limitations of both laboratory and XRF analyses, the data may show large variabilities. However, the degree of accuracy and precision obtained during the investigation should be sufficient to meet project objectives.

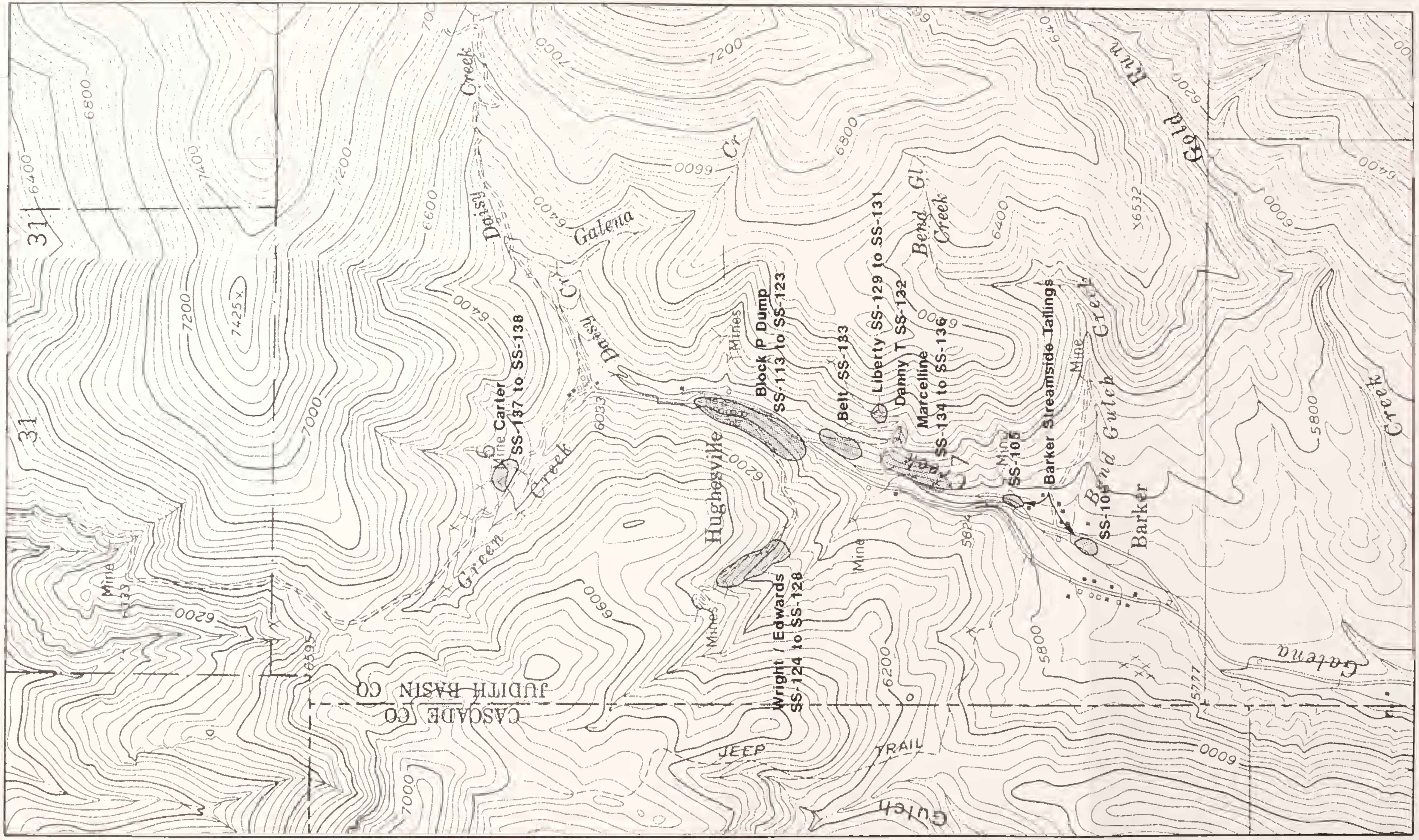
Soil/mine waste samples will be analyzed for parameters listed in Appendix A of the QAPP. The samples will be analyzed for general soil parameters, total metal concentrations, and sulfur fractionation. The method detection limits and analytical methods used for all constituents analyzed are also listed in the project QAPP (Appendix A).

6.2 SAMPLING LOCATIONS AND RATIONALE

Soil/mine waste sampling locations were selected to provide a representative cross-section of material from both native soils and potential contaminant source materials. Selected locations are based on mapping completed during the 1989 AMRB hardrock inventory of the Hughesville District. During that inventory, mine waste dumps, mine openings, and mill tailings were mapped and material volumes were estimated.

A total of 13 mine dumps and tailings features were identified as potential major contributors of contaminants to the Galena Creek and Dry Fork Belt Creek drainages

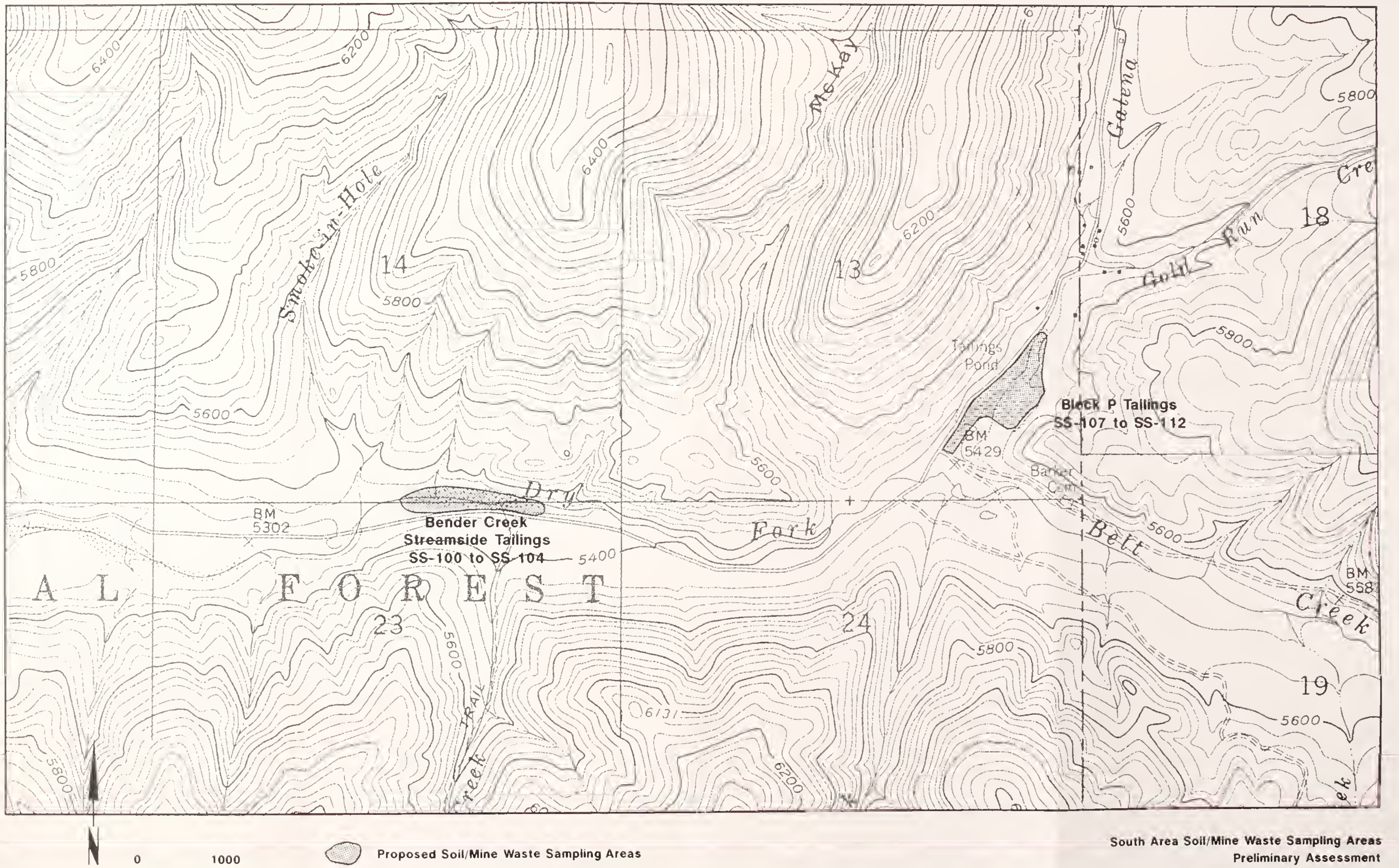
(Figures 9 and 10). Representative samples will be collected from these 13 sites from three depth intervals: 0 to 1 inch, 12 to 24 inches, and below 36 inches. Soil/waste rock samples will be collected at depth on the Block P Dump. Sample sites and the number of samples to be collected from each site is listed in Table 4.



▨ Proposed Soil/Mine Waste Sampling Areas

0 1000
Feet

North Area Soil/Mine Waste Sampling Areas
Preliminary Assessment
Hughesville Mining District, Montana
FIGURE 9



▨ Proposed Soil/Mine Waste Sampling Areas

South Area Soil/Mine Waste Sampling Areas
Preliminary Assessment
Hughesville Mining District, Montana
FIGURE 10

TABLE 4
SOIL/MINEWASTE SAMPLE AREAS AND SAMPLE QUANTITIES
Preliminary Assessment
Hughesville Mining District, Montana

SITE[1]	NO. OF SAMPLES	SITE	NO. OF SAMPLES
Streamside Tailings	10	Marcelline	3
Block P Mill Tailings	8	Liberty	3
Block P Dump	10	Carter	2
Wright/Edwards Dump	5	Danny T	1
Belt Dump	2	Native	5

(1) Locations shown on Figures 9 and 10.

Native samples will be obtained from the base of the various deposits or at the original soil surface where possible. Data from these samples will provide an indication of the magnitude of vertical movement of metals through leaching processes.

Listed sample locations and quantities are to serve only as a guide to field sampling teams. Visual observations will be made by the Field Coordinator to determine if additional sites should be sampled or if the number of samples should be increased or decreased.

6.3 SAMPLE DESIGNATION

Soil/mine waste samples will be designated as [SS-xxx-yyyy] according to the following scheme:

- Sample Type Designation: An [SS] letter designation for soil material sample;
- Sample Location Number: A unique three digit number beginning with 100 to identify the sample location;
- Sample Depth Identifier: A four digit number which indicates the vertical interval sampled. For example, a sample obtained from 12 to 24 inches would be indicated by the number 1224.

6.4 EQUIPMENT AND PROCEDURES

6.4.1 Sampling Equipment

Field crews will maintain field notebooks throughout the duration of the soil/mine waste sampling period. The field notebooks will be weather-resistant, bound, survey-type books with non-removable pages. Any comments or other notes will be entered directly into the field notebook using permanent, indelible ink. Errors will be lined through and corrected with a new entry. A summary of activities will also be entered into the field book at the end of each field day.

Soil material will be sampled using a bucket auger according to SOP-22 (Appendix A). Soil/waste rock samples will be collected at depth on the Block P Dump. These samples will be collected using a split spoon sampler during the monitoring well drilling operation. It is estimated that two to three samples of waste rock near the base of the dump will be collected. The XRF will be used and calibrated according to SOP-23 (Appendix A).

6.4.2 Decontamination

All sampling equipment will be decontaminated after soil material sampling is completed at a particular sample location. Equipment will not be decontaminated between depth interval sampling at the same sample location. Decontamination procedures will follow SOP-11 (Appendix A). Decontamination will consist of a Liquinox or equivalent wash, deionized water rinse, dilute nitric acid rinse, and a final deionized water rinse.

6.4.3 QA/QC Samples

QA/QC samples will be inserted into the sample train at a minimum frequency of 5% of the stations sampled. These samples will be submitted to the laboratory blind and will include duplicate samples and blind field standards. No cross-contamination blanks will be submitted because of the relatively low likelihood of cross-contaminating soil material samples. Matrix spikes will be prepared by the laboratory for a minimum of 5% of the samples analyzed. Further details regarding laboratory analytical protocol with respect to QA/QC requirements for the project are contained in the project QAPP.

6.5 SAMPLE HANDLING AND ANALYSIS

Soil/mine waste samples will be collected in heavy-duty polyethelene resealable bags. Approximately one gallon of sample will be collected from each depth interval. Sample bags will be marked in indelible ink with the unique sample number and the date of sampling. Samples will be placed in coolers and shipped to the analytical laboratory or to the site where XRF analyses will be performed. Chain of custody paperwork will be maintained for all samples collected.

All soil and mine waste material samples will be analyzed by an XRF spectrometer for total metal concentrations. In addition, approximately 20% of samples collected will be shipped to the laboratory for analysis of total and dissolved metal concentrations, pH, and EC.

A portion of the samples shipped to the laboratory will also be analyzed for texture and sulfur fractionation. Appendix A of the project QAPP lists analytical parameters, method detection limits, and laboratory methods to be used for material samples. A summary of sample quantities and analysis is listed in Table 3.

7.0 REFERENCES CITED

Bouwer, H., and R.C. Rice. 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research. v. 12, pp. 423-428.

Lohman, S.W. 1979. Ground-Water Hydraulics. U.S. Geological Survey Professional Paper 708. U.S. Government Printing Office, Washington D.C. 70 p.

APPENDIX A

STANDARD OPERATING PROCEDURES
(SOPs)

STANDARD OPERATING PROCEDURE
STREAMFLOW MEASUREMENT; WADING TECHNIQUE

1. Visually check wading rod, current meter (pygmy or AA types), and headsets for damage. Repair damage to equipment and replace batteries in headsets as necessary.

2. Evaluate reach of stream to determine type of meter necessary to make flow measurement. For shallow, low velocity streams, use a pygmy-type current meter; for relatively deep, higher velocity streams, use a standard AA-type meter.

3. Perform spin test on selected meter; the cups on the pygmy meter should spin continuously for at least 30 seconds; on the AA meter, the cups should spin for at least two minutes. If the current meter fails the spin test, lubricate and adjust as necessary to achieve desired results.

4. Attach current meter and head set to wading rod. Check the electric connection between the current meter and headset by spinning cups on the current meter and listening for clicks in the head phone. Adjust equipment as necessary such that a clear click is heard upon every revolution of the cups.

5. Anchor surveyor's tape tautly across the stream perpendicular to the direction of streamflow and attach on either side of the stream. Provide at least one foot of clearance between the water surface and surveyor's tape.

6. Divide the cross-section of the stream into 20 to 30 partial sections based on values noted on the surveyor's tape denoting edge of water on each side of the stream. Concentrate partial flow measurement sections in areas of the stream cross-section containing the majority of flow so that no one section contains more than 5% of the flow.

7. Person wading in stream calls out to data recorder on shore the location of the first measuring point with respect to the surveyor's tape. Person in stream measures water depth at that vertical, using wading rod, to the nearest one-hundredth of a foot, if possible.

8. Data recorder calls out height(s) above the streambed at which velocity measurements are to be made. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water column height. For water columns less than 2.5 feet deep, a single measurement of velocity at 40 percent of the water column height will suffice. Person wading adjusts height of current meter on the wading rod accordingly.

9. Person wading stands downstream of the surveyor's tape, facing upstream, holding the wading rod vertical in the water with the current meter facing directly into the current. Person should not stand directly behind the meter but either to the left or right so as not to influence velocity readings.

10. Person wading counts clicks at each vertical for a minimum of 40 seconds and calls final tally of both number of clicks and time to data recorder. Click count should correlate with velocity chart provided with each meter.

11. Repeat procedure at each vertical.

12. Data recorder reduces data on-site and records other appropriate information on the field form.

STANDARD OPERATING PROCEDURE
SURFACE WATER SAMPLING

EQUAL DISCHARGE INTEGRATED SAMPLING

1. Visually check DH-48 or D-74 sediment sampler for damage. Replace or repair parts as necessary.

2. Decontaminate all parts of sediment sampler utilized including nozzle, body, gasket, sample bottle, and handle using the procedure outlined in SOP-11.

3. Following streamflow measurement, and utilizing the same tag line or surveyor's tape stretched across the stream, divide the stream into four or more sections of equal discharge based on stream gaging results. At the mid point of each equi-discharge section, lower the sediment sampler into the stream with one continuous motion making sure the sample handle is vertical. Lower the sediment sampler to the streambed at a rate based on the rating curve for the nozzle size used and the velocity of the stream. The sample bottle should be just under half full upon encountering the streambed. Raise the sampler at a rate similar to the descent rate. The sample bottle should not be completely full upon removal from the stream. Pour contents of sediment sample bottle into a churn splitter or into an appropriately sized compositing container.

4. Repeat procedure for the other equal discharge sections identified, composite collected samples into the churn splitter.

5. Mix composite sample in the churn splitter and fill total metals and acid soluble metals first.

6. Fill out appropriate field form documenting sample location, time, and other pertinent information prior to leaving sampling site.

GRAB SAMPLING

1. Decontaminate sampling container in accordance with SOP-11.

2. Locate sampling site at a point in the stream exhibiting greatest flow and/or highest velocity.

3. Submerge sample container at sampling point such that mouth of container is under water surface 2 to 3 inches if possible. Allow container to fill partially; rinse container by shaking and discharge this water. Repeat this procedure three times.

4. Collect sample and transfer into compositing container. Transfer water from compositing container into sampling bottles.

5. Fill out appropriate field form(s) documenting sample location, time, and other pertinent information prior to leaving sampling site.

SURFACE SAMPLING

1. This sampling procedure is to be used when sampling for organic constituents that float on top of water (e.g. oil and grease).

2. Decontaminate sampling container in accordance with SOP-11. The sampling container should be a wide mouth jar.

3. Submerge the sampling container in such a manner that leaves the mouth of the container 1/2 out of the water. Wait for container to fill.

4. Transfer directly into sampling bottles.

5. Fill out appropriate field form(s) documenting sampling location, time and other pertinent information prior to leaving the sampling site.

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENT OF ELECTRICAL CONDUCTANCE

Field Procedure

1. Check red line and zero point on meter. Adjust as necessary.

2. Rinse decontaminated glass beaker with approximately 50 milliliters of sample water three times.

3. Place water sample in decontaminated glass beaker.

4. Rinse probe with DI water and place conductivity probe in sample water.

5. Immerse conductivity probe in sample so that vent hole is submerged. Move probe around in sample to displace any air bubbles. Turn instrument on to appropriate scale for sample analyzed. Multiply reading by the correct multiplier from the dial and record to the nearest ten microsemins/centimeter. Measure sample temperature to nearest 0.5°C from conductivity meter. Record temperature.

6. Remove probe from sample and rinse probe with DI water.

Instrument Calibration

At the beginning and end of each day of sampling, determine cell constant in the field.

1. Rinse probe with deionized water.

2. Measure conductivity of two KCl solution standards which bracket expected sample values.

3. Measure temperature of both KCl solution standards.

4. Calculate cell constant for each standard and average the two values. The cell constant is the ratio of the computed conductivity to the measured conductivity of the standard KCl solution. Use this averaged constant and measured field temperatures and conductivities to calculate conductivity at 25°C for each sample taken during the day.

Maintenance

1. Store meter in its case during transport. If stored for long periods of time, immerse probe in distilled water.

2. Check batteries before taking meter into the field. Carry spare batteries and screwdriver.

3. Inspect conductivity electrodes on a monthly basis for cracks or other damage.

4. If platinum black has flaked off, a sharp end point cannot be achieved or readings are erratic. Return probe to factory so it can be replatinized.

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENT OF pH

Field Procedures

1. Rinse decontaminated glass beaker with approximately 50 milliliters of sample water three times.

2. Rinse pH electrode with deionized water.

3. Check meter using standard that is nearest the expected pH. If not within 0.1 pH units re-calibrate meter using appropriate standards.

4. Fill beaker with sample water.

5. Immerse electrode and temperature probe in sample while swirling the sample to provide thorough mixing. Turn on meter. Electrode filler level should be 1/2-inch above sampling surface level. Read pH to nearest 0.1 unit once the reading has stabilized.

6. Record sample pH. Note any problems such as erratic readings.

7. Rinse probe with DI water and store according to manufacturer's directions.

Instrument Calibration

1. Calibrate pH meter in the field at the beginning of each day of field work when pH will be measured, or when the standard check is out of acceptable bounds. Calibrate using following procedure:

   - Rinse pH electrode and temperature probe with distilled water.

   - Immerse electrode and temperature probe in beaker of commercial calibration solution of pH at or below that expected for the samples.

   - Calibrate meter to appropriate pH.

   - Remove electrode and temperature probe from solution, rinse with distilled water, air dry.

   - Immerse electrode and temperature probe in second calibration solution having a pH 2 to 3 units higher or lower than the first, calibrate meter to solution.

- Measure pH of one of the calibration solutions. If measured value differs from expected value by more than 0.1 units, obtain fresh calibration solutions and recalculate. If discrepancy persists, begin trouble-shooting procedures following meter operating instructions: check batteries, connections, etc. If meter checks out, inspect combination electrode. Clean and refill as necessary.

Maintenance

1. Store meter in its case with electrode immersed in a pH 7 buffer solution.

2. Inspect electrode weekly.

   - Plug of filler hole should be firmly seated when meter is stored for a week or more.

   - Check glass electrode for cracks or scratches.

3. Check batteries each time meter is used. Carry a spare battery pack and a screwdriver into the field in the pH meter case.

4. Check pH meter monthly with a pH meter tester and adjust as necessary.

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENT OF WATER TEMPERATURE

1. Carry two NBS-calibrated thermometers inside cases, into the field.

2. Check thermometer for cracks or gaps in the mercury. Do not use thermometers if either cracks or gaps are visible.

3. When possible, measure temperature of surface water at midstream submersing the thermometer for approximately one minute or until temperature stabilizes.

4. When in situ temperature measurements are not possible, draw sample of at least 200 mL into a decontaminated beaker or sample bottle as soon after sampling as possible.

5. Place thermometer in sample. Do not allow thermometer bulb to touch sides of beaker. Allow to equilibrate (about 1 minute).

6. Record temperature to nearest $0.5^{0}C$ in field log book or on field data sheet.

7. Rinse thermometer with deionized water.

8. On a quarterly basis, check field thermometers against a NBS-certified laboratory thermometer. Agreement should be within $0.5^{0}C$.

STANDARD OPERATING PROCEDURE
SAMPLE PACKAGING AND SHIPPING

All samples collected should be packaged and/or shipped utilizing the following procedures.

Packaging

1. Place each labelled sample bottles in a zip lock bags and then in a high quality cooler containing two large containers of recently frozen blue ice (where applicable), making sure the cooler drain plug is taped shut both inside and outside.

2. Position the sample bottles upright and surround the samples with noncombustible, absorbent, cushioning material for stability during transport.

3. Place the laboratory/sampling paperwork in a ziplock bag and tape it to the inside lid of the shipping container (see Shipping Papers).

4. Close and seal the cooler with at least two signed and dated custody seals and sealer tape. Tape cooler shut utilizing fiberglass tape.

5. Secure Air Bill to cooler and ship via express air service.

6. Notify project manager of shipment.

Marking/Labeling

7. Use abbreviations only where specified.

8. Place the following information either hand printed or in label form, on the outside container:

   o Laboratory name and address (on Air Bill)

   o Return cooler to: (name and address)

9. Secure "This End Up" and "Fragile" stickers clearly on top of the shipping container. Put upward pointing arrows on all four sides of the container. No other marking or labeling is required.

Shipping Papers

10. No DOT shipping papers are required. All field samples, (natural and QC), will be documented with the following forms. These forms will be placed in ziplock bags and taped to the inside lid of the same cooler as the samples to which they pertain.

    - Chain-of-custody form
    - Special Analytical Service (where applicable)
    - Inorganic Traffic Reports (where applicable)
    - Organic Traffic Reports (where applicable)

STANDARD OPERATING PROCEDURE
EQUIPMENT DECONTAMINATION

The purpose of this section is to describe general decontamination procedures for field equipment in contact with mine/mill tailings, soil, or water. During field sampling activities, sampling equipment will become contaminated after it is used. Sampling equipment must be decontaminated between sample collection points if it is not disposable.

Field personnel must wear disposable examination gloves while decontaminating equipment at the project site. Change gloves between every sample. Every precaution must be taken by personnel to prevent contaminating themselves with the wash water and rinse water used in the decontamination process.

Table A-1 lists equipment and liquids necessary to decontaminate field equipment.

The following should be done in order to complete thorough decontamination:

1. Set up the decontamination zone approximately 15 feet upwind from the sampling area. This area will be designated by the field crew leader.

2. Visually inspect sampling equipment for contamination; use stiff brush to remove visible material.

3. The general decontamination sequence for field equipment includes: wash with Liquinox or its equivalent; DI water rinse; dilute nitric acid rinse; DI water rinse; rinse with sample water three times.

4. Rinse equipment with methanol in place of the nitric rinse if sampling for organic contamination. Follow with a DI water rinse.

5. Decontaminated equipment that is to be used for sampling organics should be wrapped in aluminum foil if not used immediately.

6. Clean outside of sample container after filling.

Alternatively, field equipment can be decontaminated by steam cleaning, rinsing with dilute nitric acid, and rinsing with deionized water.

All disposable items (e.g., paper towels, examination gloves, wash cloths) should be deposited into a garbage bag and disposed of in an approved landfill. Contaminated wash water does not have to be collected.

If vehicles used during sampling become contaminated, wash both inside and outside as necessary.

TABLE A-1. EQUIPMENT LIST FOR DECONTAMINATION

2-gallon plastic tubs
5-gallon plastic water-container
5-gallon carboy DI water
1-gallon cube of 10% HNO_3
Paper towels
Liquinox (soap)
Hard bristle brushes
Garbage bags
Latex gloves
Squeeze bottles
Methanol

STANDARD OPERATING PROCEDURE
QC SAMPLES

QC samples do not have any unique identifying codes that would enable the contract lab or others to bias these samples in any way. There are, however, differences in blank and standard samples which might separate them from the rest of the sample train. The sampling team will strive for uniformity in sampling technique to limit sampling error. The QC samples will be identified only on the SAMPLE IDENTIFICATION MATRIX. The codes on the matrix sheet are as follows.

N - Natural Sample
R - Replicate - Duplicate Sample
BB - Bottle Blank
WB - Cross Contamination Blank
BFS- Blind Field Standard
KB - Kimwipe Blank
TB - Travel Blank

In general, QC samples will be inserted into the sample train on a one in twenty basis or one per day per sampling crew, whichever results in more QA/QC samples.

1. A duplicate sample will be a second sample taken from the same media at the same time.

2. A bottle blank will be deionized water placed directly into the sample bottles. It is preferable to fill bottle blank off-site.

3. A cross contamination blank will be deionized water run through all sampling equipment or a Kimwipe wiped over decontaminated equipment and then placed into sample bottles.

4. A field standard will be an EPA approved standard prepared in the laboratory and entered into the sample train.

5. A Kimwipe blank will be a Kimwipe obtained directly from its packaging and inserted into a sample container.

6. A travel blank will be a ultra pure water sample prepared at the analytical laboratory and shipped to the sampling team; the blank must travel in a cooler with the sampling team when sampling for volatile organic compounds.

Each field crew leader will be responsible for all QC samples prepared by that crew.

STANDARD OPERATING PROCEDURE
MONITORING WELL CONSTRUCTION

1. Arrive on-site with properly sized drilling equipment and materials for site conditions. All drilling equipment and materials should be properly decontaminated prior to its arrival on-site. Decontamination usually includes steam - or hot water-cleaning methods.

2. Drilling muds or drilling solutions of any kind are not to be used during drilling activities in conjunction with monitoring well construction. Acceptable drilling techniques include air-rotary, cable tool, or hollow-stem auger. If unconsolidated material is encountered, it may be necessary to drive steel casing during drilling to maintain borehole integrity. It is suggested threaded steel casing be used in lieu of welding joints together to minimize this source of potential well contamination. Hydraulic jacks or the drill rig can be used to pull back the steel casing following emplacement of plastic casing.

3. A detailed lithologic log shall be completed during drilling activities. Water bearing characteristics of the formations should also be denoted on the log. In addition, details of monitoring well construction should also be described on the well log including total depth, perforated interval, sizes and types of construction materials, etc.

4. Seven- or ten-inch outside diameter hollow-stem augers can used in drilling shallow exploration drill holes in many situations. Care is taken to avoid contamination due to oil and grease from the drill rig and split spoon sampler. Appropriate decontamination of the drill rig between drill holes is performed. Soil and sediment samples are collected using a standard 1.4 inch inside diameter split spoon sampler and a 140 pound drive hammer. The number of blows necessary to obtain an 18 inch length of sample is recorded on the exploration log. Appropriate decontamination of the split spoon sampler is accomplished between samples.

   Either a single- or multi-completion monitoring well can be constructed in a single borehole where hollow-stem auger drilling is not used. Backfill chemically-inert silica sand to above the perforated interval and emplace a bentonite plug above the sand following installation of factory-screened and blank PVC (stainless steel or PTFE for organics) well casing into the borehole. Where appropriate, begin pulling temporary steel casing out of borehole. Emplace silica frac sand about any other perforated sections in the borehole; install bentonite plugs above and below perforated sections. Backfill remaining well annulus with a bentonite slurry or with grout to the surface.

5. Place locking well protector over PVC casing(s) after outer steel casing has been removed from the borehole if necessary. Place bentonite plug below bottom of well protector; grout well protector in place and lock with high quality lock.

STANDARD OPERATING PROCEDURE
GROUND WATER SAMPLING

1. Inspect all sampling equipment for damage upon arriving on-site. Repair equipment as necessary.

2. Decontaminate sampling equipment by scrubbing with brush and Liquinox, solution, rinsing with dilute nitric acid, and rinsing with deionized water.

3. Sampling domestic wells:

   a. Turn-on household fixture (preferably outside faucet) and allow well to discharge for 5 to 10 minutes. Be certain discharge point is on the well-side of any water conditioning device or screen.

   b. Monitor field parameters periodically during discharge period. When field parameters are within plus or minus five percent over three consecutive readings, the well is ready for sampling.

   c. Fill sample containers and add sample preservatives as appropriate. Do not collect samples through rubber hoses. Samples should be collected directly from hydrant or faucet. Perform field parameter tests.

   d. Field filter sample water in accordance with SOP-04 if appropriate. Add preservations as appropriate.

   e. Complete field forms in accordance with SOP-10.

4. Sampling monitoring wells:

   a. Evacuate monitoring wells with bailer or pump; monitor field parameters for consistency during evacuation process. Remove a minimum of three bore volumes of water from the monitoring well.

   b. Following well evacuation, install decontaminated bladder pump into or above perforated zone in well; commence pumping and monitor field parameters for consistency using field parameter box. Alternatively, a decontaminated bailer may use to collect the sample. Well is ready for sampling when field parameters are within plus or minus five percent on three consecutive readings.

   c. Field filter sample water in accordance with SOP-04 if appropriate. Add sample preservatives as appropriate; fill out field forms in accordance with SOP-10.

STANDARD OPERATING PROCEDURE
SOIL SAMPLE COLLECTION AND HORIZON DESCRIPTION

SURFACE SAMPLING

Surface soil/tailings samples are collected from the surface to a depth of one inch. Sufficient sample will be collected for the analysis that will be performed. Soil descriptions will be completed for each collected soil sample in accordance with the procedures outlined in the unified soil classification system (ASTM D2487). Descriptions shall be recorded in field books or on standard morphological description logs.

Each sample will be deposited directly onto a plastic sheet. The sample will be broken up. A representative sample will be obtained by alternately pulling one corner of the plastic sheet over the opposite corner a minimum of 25 times. The sample will then be transferred to the appropriate container.

When sampling soil for organics the samples will be deposited directly into the sample container for shipment to the laboratory without mixing.

All equipment used in the sampling of surface soils will be decontaminated using the procedures in SOP-11. All necessary paperwork will be filled out in accordance with SOP-12.

SUBSURFACE SAMPLING

Subsurface sampling will be completed using either a bucket auger or a split spoon sampler. Sampling procedures using these types of equipment is described below:

Bucket Auger

1. Arrive on-site equipped with a stainless steel auger rod and four sizes of stainless steel augers (e.g. 2-inch, 4-inch, 6-inch, and 8-inch).

2 Decontaminate augers and handle using methods described in SOP-011 or with a steam cleaner followed with dilute nitric acid and deionized water rinses.

3. Using largest auger, drill down a maximum of three feet in six inch increments, salvaging material as augering proceeds. Install temporary decontaminated PVC casing with a diameter slightly smaller than borehole. Using the next size smaller bucket auger, repeat the process. This telescoping procedure will minimize cross contamination of the various lithologies encountered in the soil profile.

4. Select sample intervals for packaging for laboratory analysis in accordance with procedures desccribed in the project work plan or sampling and analysis plan. Composite and mix subsamples; obtain a portion of composited sample for XRF determinations or other needs.

5. Fill out appropriate paper work and bottle labels as necessary prior to leaving site.

6. Decontaminate all equipment between sample locations.

Split Spoon Sampler

1. Arrive on-site equipped with at least two standard 1.4 inch inside diameter split spoon samplers. If geotechnical information is desired, a 140 pound drive hammer is required.

2. Decontaminate split spoon sampler in accordance with SOP-011 or with a steam cleaner and dilute nitric acid and deionized water rinses.

3. Install sampler into borehole until the top of the undrilled formation is encountered. Using 140 pound drop hammer or by other means, hammer split spoon sampler into formation approximately 18 inches. Record number of blow counts to complete sampling over each 18-inch interval, as necessary. Retrieve sampler and place on work table. Using the other sampler, repeat this sequence.

4. Record lithology and percent recovery from cores retrieved from split spoon sampler.

5. Based upon the project work plan or sampling and analysis plan, composite like core intervals. Mix sample thoroughly and obtain a subsample for XRF and field parameter determinations as necessary.

6. Decontaminate sampling equipment between each interval sampled and between sampling sites.

STANDARD OPERATING PROCEDURE
X-RAY FLUORESCENCE SPECTROMETER (XRF) USE AND CALIBRATION

The chemical characterization of soil samples in the field will be determined by the field portable X-ray fluorescence (XRF) Spectrometer ATX-100 instrument manufactured by Aurora Tech, Inc, Salt Lake City, Utah. The instrument uses low level self-contained and shielded radioactive sources that produce spectral peaks whose position (energy level) is specific to an individual element and whose peak height or area which is indicative of the concentration of that element within the area exposed to the source. Two sources will be used, cadmium-109 (15 millicuries) and Iron-55 (100 millicuries) implaced by the manufacturer. These sources allow semiquantitative determination of the copper, zinc, arsenic, iron, manganese and lead concentrations. Additional elements that will be monitored include chromium, barium, cobalt, nickel, selenium, and molybdenum.

The detection limit for each parameter is a function of source strength, geometry/particle size, counting time, and the concentration of other elements. Since the source strength and instrument geometry are constants, the detection limit is dependent on geometry/particle size, counting time, and concentration. It has been demonstrated that 80 mesh particle size dominantly composed of a siliceous or calcareous skeletal matrix will give analytical results within 20 percent. The larger the particle size, the larger the error. A rock made up of fine-grained minerals, however, will essentially have the same precision and accuracy as a finely ground sample. Soil samples will be screened and all particles greater than 2 mm (No. 10 sieve) will be removed.

The counting time also affects the detection limit. In general, the longer the counting time, the lower the detection limit, and certainly the higher the precision and accuracy. The instrument has controllable time units of 10, 30, 100, 300, and manual control seconds. The 30 second counting time will likely be the standard for this test. The time may change for either or both sources depending on the actual sample matrix encountered in the field.

The primary operator will receive one day’s training on the proper use of the instrument particularly for health and safety purposes. The manufacturer’s statement on radiation safety is also attached. Each operator will have a gamma film badge service (monthly) and will have the dates and times used logged in the record book specifically kept for this purpose.

Calibration of the unit will be provided by the following method.

The XRF will be calibrated before being taken in the field by developing response curves of index values verses actual concentrations of metals in soils. Numerous samples have been analyzed through the CLP program for metals content and splits of these samples are archived in Helena. These splits will be used to develop the response curves so that the index values that are generated in the field can be converted into concentrations. These concentrations will then be used to help direct the soil sampling program for laboratory samples. The XRF will also be calibrated using the internal standards as recommended by the manufacturer. This internal calibration will be performed, each day of use, in the morning, at noon and at the end of the day. Time, temperature and calibration data will be noted during each calibration in the field logbook.

Data for Cu, Zn, Fe, Mn, Pb, As, and Ni will be recorded in the field logbook or on standard forms.

To obtain the best quantitative XRF results, a uniform volume of soil material of generally the same particle size will be used. The sample should be prepared in the following manner: (1) Disaggregate and homogenize field moist sample, foreign objects such as rocks, twigs, roots, etc.; (2) Dry sample preferably overnight in an over set at approximately 105°C; (3) Cool sample to room temperature; (4) Sieve sample through a 2 mm nonmetallic sieve; (5) homogenize sieved sample; and, (6) Place sample in a 2-inch petri dish.

The soil material will be well packed in the petri dish and the top surface should be uniformly smoothed to the level of the petri dish edges. The head of the XRF should then be placed over the petri dish.

If soil is sticking to the XRF, place a piece of Saran Wrap over the petri dish. If any dust sticks to the head of the XRF, clean it with a fine-bristle paint brush.

STANDARD OPERATING PROCEDURE
AQUIFER TESTING

Pumping Tests

1. Measure water levels in the pumping well and all observation wells daily for several days prior to the test to document water table fluctuation. It is preferable to install a continuous water level recorder to obtain this information.

2. Arrive on-site with all necessary equipment decontaminated and in good repair.

3. Set-up equipment; insure discharge hose/piping is directed away from test area such that the discharge will not influence the test. Obtain any necessary sanitary sewer or other discharge permits.

4. Choose pump size based on expected well yield reported from previous pumping tests or from the well development logs. It is important to stress the aquifer during the pumping test yet have enough available drawdown for the expected duration of the test.

5. Obtain water level data prior to the test in the pumping well and in all observation wells. Record all data on standardized field forms.

6. Begin trial pumping test by maintaining a constant discharge rate and measuring drawdown in the pumping well with an electric well probe or a pressure transducer. Determine if pumping rate is appropriate for the length of the test. Adjust discharge rate as necessary. Terminate trial test and allow water levels to recover to prepumping elevations.

7. Prepare for constant discharge test by coordinating all personnel involved. Collect water level data every 30 seconds for the first five minutes of the test, every minute for the next five minutes, every two minutes for minutes 10 through 20 of the test, every five minutes for minutes 20 through 40, every 10 minutes for minutes 40 through 60, every 15 minutes for minutes 60 through 100, every 30 minutes for minutes 100 through 1000, and every 60 minutes for the remainder of the test. Following termination of the constant discharge test, collect water level recovery data in a sequence similar to that above with the most frequent measurements obtained early in the recovery tests.

8. During the constant discharge test, obtain measurements of discharge periodically and record on field forms. Adjust discharge as necessary to maintain consistency. Measure field parameters, including pH, SC, and temperature at the time of discharge measurements.

9. Record all data on standard field forms and plot drawdown and recovery curves in the field in accordance with methods described in Lohman (1972) or other appropriate techniques as conditions or aquifer type warrant. Note any irregularities in the test on field forms.

10. Upon completion of aquifer testing, decontaminate all equipment prior to exiting the project area.

Reference:

Lohman, S.W. 1972. Ground Water Hydraulics. U.S. Geological Survey Professional Paper 708. Washington.

Slug Testing

1. Arrive on-site with all equipment decontaminated and in good repair.

2. Insert pressure transducer (if applicable) into well to be tested and allow to stabilize. Measure and record static water level prior to initiation of test.

3. Perform test by either withdrawing a known volume of water or inserting a cylinder of know dimensions. Record water level recovery data at frequent intervals on a standardized field form. Measurement frequency should continuously initially, decreasing to every five minutes after approximately 15 minutes into the test. It is preferable to use a continuously recording pressure transducer to record recovery data as data obtained early in the test are typically the most valuable data for slug testing. Record data until recovery is about 95 percent complete.

4. Analyze recorded data in the field in accordance with procedures described in U.S. Department of the Navy (1974), Hvorslev (1951) and/or any other appropriate techniques for the type aquifer being tested.

5. Note any irregularities in test procedures on the field forms.

6. Decontaminate all field equipment prior to leaving each site.

References:

U.S. Department of the Navy. 1974. Naval Facilities Engineering Command

Hvorslev, J.M. 1951. Time lag and soil permeability in ground water observations. Bulletin 36. U.S. Corps of Engineers, Waterways Exp. Sta., Vicksburg, MS.

FINAL

SAMPLING AND ANALYSIS PLAN

PART 2: QUALITY ASSURANCE PROJECT PLAN

HUGHESVILLE MINING DISTRICT
GALENA CREEK DRAINAGE BASIN
REMOVAL SITE EVALUATION
PRELIMINARY ASSESSMENT

Prepared for:

Montana Department of State Lands
Abandoned Mine Reclamation Bureau
Helena, Montana

Prepared by:

Chen-Northern, Inc.
Helena, Montana

November, 1990

Copy 4 of 7

TABLE OF CONTENTS

1.0 PROJECT DESCRIPTION 1
    1.1 OBJECTIVES OF THE QUALITY ASSURANCE PROJECT PLAN 1
    1.2 OBJECTIVES OF THE PRELIMINARY ASSESSMENT 2

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES 4

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT 6

4.0 SAMPLING PROCEDURES 9
    4.1 SAMPLING PROTOCOL 9
    4.2 FIELD INSTRUMENTS 10
    4.3 SAMPLE HANDLING, CONTROL, DOCUMENTATION AND SHIPPING 10

5.0 CALIBRATION PROCEDURES 12

6.0 ANALYTICAL PROCEDURES 13

7.0 DATA REDUCTION, VALIDATION, AND REPORTING 14

8.0 INTERNAL QUALITY CONTROL 16

9.0 PERFORMANCE AND SYSTEMS AUDITS 17

10.0 PREVENTIVE MAINTENANCE 18

11.0 ROUTINE DATA ASSESSMENT PROCEDURES 19

12.0 CORRECTIVE ACTIONS 20

13.0 QA PROJECT REPORTS 21

LIST OF APPENDICES

APPENDIX A   ANALYTICAL METHODS AND DETECTION LIMITS FOR INORGANIC ANALYSIS

1.0 PROJECT DESCRIPTION

The Hughesville Mining District, located in the Little Belt Mountains of Cascade and Judith Basin Counties, Montana, has been impacted by past mining and milling activities. Numerous inactive lead-silver mines, mine wastes dumps, and a mill site with two large tailings ponds impact approximately twelve miles of Galena Creek and the Dry Fork of Belt Creek below Galena Creek. These drainages do not support aquatic life as a result of degraded surface water. Impacts to the surface water systems are the result of input of discharge from abandoned mine shafts and adits, leachate from mine/mill waste and tailings dumps, and erosion of mine waste from disturbed areas.

The Department of State Lands, Abandoned Mine Reclamation (AMR) Program has targeted the Hughesville Mining District for clean-up efforts. The objective of the reclamation efforts is to improve the water quality of Galena and Dry Fork Belt Creeks by controlling acid mine drainage and the rate of sedimentation into the watershed.

1.1 OBJECTIVES OF THE QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) presents the policies, organizational structure, objectives and specific quality assurance (QA) and quality control (QC) activities designed to achieve the goals specified for this project. Quality assurance is defined as the integrated program designed for assuring reliability of monitoring and measurement data. Quality control is defined as the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measuring process.

This QAPP addresses the requirements set forth in the U.S. Environmental Protection Agency's (EPA) National Contingency Plan (NCP). QA procedures such as data tracking and reviewing will be implemented as necessary to ensure that all project work is performed in accordance with professional standards, the NCP, and other applicable governmental regulations and guidelines. The general quality assurance goal of the

sampling and testing program is to provide environmental data of acceptable and documentable quality. In order to meet this goal, data shall be:

- Representative of actual conditions and comparable to previous and subsequent data and other studies pertinent to the site;
- Complete to the extent that necessary conclusions concerning the general characteristics of the site may be reached;
- Have defined quantitative statistical significance in terms of precision and accuracy established for the project.

This QAPP supports preliminary assessment activities for the Galena Creek drainage by formalizing sound quality assurance/quality control procedures that will ensure control and documentation of the quality of all data generated during the preliminary assessment. This QAPP is a companion document to the Preliminary Assessment Work Plan and project Field Sampling Plan (FSP). These three documents will be used in concert to guide study efforts associated with this project.

1.2 OBJECTIVES OF THE PRELIMINARY ASSESSMENT

Objectives of the preliminary assessment to be conducted in the Hughesville Mining District include the following:

- Collect and collate baseline information to efficiently plan and conduct comprehensive site investigations and studies of applicable removal alternatives which fully address the requirements of the NCP and EPA's guidance for removal activities.
- Provide preliminary identification of operable units within the study area. An operable unit is defined as a discrete action that comprises an incremental step toward comprehensively addressing site problems. The cleanup of a

site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographic portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.

- Provide a rational basis to prioritize subsequent removal activities within the study area.

Field data collection efforts to be completed during the Galena Creek drainage preliminary assessment will include: surface water sampling and flow measurement; groundwater monitoring well installation, sampling, and testing; and, soils and mine waste sampling. All laboratory analyses will be completed by Chen-Northern's Billings laboratory.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Chen-Northern, Inc. will provide the technical expertise to maintain quality assurance throughout the project. Chen-Northern's responsibilities will include oversight on project performance and implementation of necessary actions and adjustments to ensure program objectives are achieved. The Montana Department of State Lands, Abandoned Mine Reclamation Bureau (AMRB) will review QA requirements, problems, and requests, and will ensure the project is performed in accordance with provisions contained in the NCP.

The primary persons responsible for project quality assurance and review are Chen-Northern's Site Project Manager and AMRB's Project Manager. Where quality assurance problems or deficiencies requiring special action are uncovered, the Project Manager will consult the Quality Assurance coordinator in order to identify the appropriate corrective action(s). The Site Project Manager will then be responsible for implementing corrective action(s) after concurrence is reached with the AMRB.

The QA organization and personnel responsible for assessing the proper implementation of the QAPP are listed below:

Officer-in-Charge:	Susan McAnally Department of State Lands AMRB
Project Manager:	Myles Grotbo Chen-Northern, Inc.
Project Quality Assurance Coordinator:	Patricia Bugosh Chen-Northern, Inc.
Project Safety Officer:	Kathy Smit Chen-Northern, Inc.

Project Hydrogeologist:	Pat Dunlavy Chen-Northern, Inc.
Project Engineer:	Dale Ortman Chen-Northern, Inc.
Field Supervisor:	Michael Cormier Chen-Northern, Inc.
Community Relations:	Susan McAnally Department of State Lands AMRB
Field Personnel:	To Be Named
Analytical Laboratory:	Chen-Northern, Inc. Billings, MT

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

The overall QA objective for measurement data is to ensure that data of known and acceptable quality are provided. QA objectives for measurement are usually expressed in terms of comparability, completeness, representativeness, accuracy, precision, and detection limits. Definitions of these characteristics are as follows:

COMPARABILITY - Comparability is the confidence with which one data set can be compared to another. Comparability may be assured by using approved sampling plans, standardizing analytical and field procedures, and using identical units for reported data. All data in a particular data set will be obtained by the same methods to insure comparability of the results.

COMPLETENESS - Completeness is a measure of the amount of valid data expressed as a percentage obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Field and analytical data may be specified at different completeness levels. The completeness criteria should be defined so as to be consistent with the project data quality objectives. For this study a completeness of 90% is projected. If a completeness of 90% is not achieved, reanalyses or resampling may be required.

REPRESENTATIVENESS - Representativeness is a measure of how closely the samples collected represent the population from which they were obtained. Representativeness is accomplished by:

- Choosing the number of samples, sampling locations, and the sampling procedures that will produce results that depict, as accurately and precisely as possible, the matrix and conditions being measured;

- Developing protocols for storage, preservation, and transportation that preserve the representativeness of the collected samples;

- Analyzing samples within prescribed holding time; and,
- Using methods to document that protocols have been followed and that samples are properly identified so that their integrity is maintained.

Procedures to insure collected samples are representative are contained in the project FSP.

ACCURACY - Accuracy is a measure of the bias in a system. To ensure accuracy of all field data collected, instruments used in the sampling efforts will be maintained and calibrated as specified in this QAPP and the FSP. Reference samples (blind field standards) will be utilized as QC samples to assess laboratory accuracy. Blind field standards are certified materials, with known concentrations, produced by agencies such as EPA and the National Bureau of Standards (NBS). These samples are submitted blind, along with the natural samples.

Computer programs will be used to store and report analytical data. Data will be entered into the computer data base from hard copy information by two separate individuals. A computer cross-check program will be used to identify any anomalies in the two data bases. Corrections of inappropriate or erroneous entries will be completed and a final data base will be prepared. The accuracy of data entry will also be checked by proof-reading all output and comparing against the validated data.

PRECISION - Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Duplicate samples will be collected at a specified frequency to determine precision of laboratory methods. In addition, cross-contamination blanks will be collected to monitor field collection procedures. Actual collection frequencies are defined in the project FSP. QC samples will be incorporated into the sample train for every sample matrix, at least once per collection period. All field instruments will be calibrated according to manufacturer's specifications.

DETECTION LIMITS - The analytical detection limits for inorganic analyses to be completed on the Hughesville Project are presented in Appendix A. Use of these detection limits will allow the data that are produced under this QAPP to be compared with data that are being generated on other AMR projects. In addition, use of the detection limits included in Appendix A will allow evaluation of certain Applicable and/or Relevant and Appropriate Regulations (ARARs) for the project.

4.0 SAMPLING PROCEDURES

The objective of environmental sampling to be completed in conjunction with this Preliminary Assessment is to obtain samples that represent the environment being investigated. Trace levels of contaminants from external sources can be eliminated through the use of experienced field personnel, good sampling techniques, proper selection of sampling equipment, and adequate decontamination.

4.1 SAMPLING PROTOCOL

Field measurements and sampling will be performed in accordance with generally accepted procedures. Details of these procedures are included in the project FSP and this QAPP and include:

- Description of techniques or guidelines used to select sampling sites, plus maps or tables showing sampling sites
- Inclusion of specific sampling procedures to be used
- Use of charts, flow diagrams, or tables delineating sampling program operations
- A description of containers, source of containers, procedures, reagents, source of reagents, etc., used for sample collection, preservation, transport, and storage
- Descriptions of methods for preparing sampling equipment and containers to avoid sample contamination and specific decontamination procedures
- Description of sample preservation methods and holding times

- A description of time considerations for shipping samples promptly to the laboratory
- A listing of forms, notebooks, and procedures to be used to record sample history, sampling conditions and analyses to be performed

4.2 FIELD INSTRUMENTS

The following equipment will be used to perform field sampling during this investigation:

- pH meter (for determination of water pH)
- Specific conductivity meter (for determination of electrical conductivity (EC) of water)
- Thermometer (for determination of water temperature)
- Current meter (for measuring streamflow)
- Transducer (for measuring pressure changes in conjunction with slug tests)
- XRF (for semiquantitative analysis of metals in soils)

4.3 SAMPLE HANDLING, CONTROL, DOCUMENTATION AND SHIPPING

The standard operating procedures for sample type delineation, handling, shipping and related matters are presented in the project FSP. The purpose of implementing these procedures is to maintain the integrity of all samples during collection, transportation, analysis, and reporting. These procedures are necessary to validate the history of sample data from collection through reporting by providing adequate documentation.

The specific procedures for sample handling and labeling were developed in consideration of the type of sample collected (environmental or hazardous). If the sample is deemed to be hazardous, the degree of contamination will be noted. The degree of contamination or concentration of contamination is specified as low, medium or high. The sample type will be delineated at the time of collection based on site specific conditions. Samples collected away from known contaminated areas can be treated as low concentration environmental samples. The decision for sample type determination will be made by the Field Sampling Coordinator in consultation with the Site Safety Officer.

Samples will be packaged and shipped in watertight coolers, adequately packed to avoid damage under normal handling and shall be delivered to the laboratory so that the requested analyses can be performed within the specified allowable holding time. Samples will be accompanied by a sample analysis request form. The request form will list the variables to be analyzed by the laboratory and total number and type of samples shipped for analysis. Authorized laboratory personnel will acknowledge receipt of shipment by signing and dating the form and returning a copy to the QA Document Control Officer.

5.0 CALIBRATION PROCEDURES

All field and laboratory equipment used during this project will be operated, maintained, calibrated, and standardized in accordance with manufacturers' recommendations or industry accepted practices. Methods and frequencies of equipment operation, maintenance, calibration and standardization will be described in the project FSP. Each piece of field equipment will have a protocol containing:

- Standard operating procedures
- Preventative maintenance procedures
- Calibration methods and frequencies, including the preparation of calibration (standard) solutions
- Standardization procedures
- Precision and accuracy assessment procedures

6.0 ANALYTICAL PROCEDURES

For samples collected during this project, analytical procedures in accordance with EPA methods will be used. These methods are identified in Appendix A. All laboratory QA/QC operations prescribed for a particular procedure will be used.

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

The objectives of the data validation are to identify any unreliable or invalid laboratory measurements and to determine the quality of the analytical data. Two criteria are used to validate and reduce chemical test data; accuracy and precision. Other considerations such as completeness, representativeness, and comparability depend on accuracy and/or precision and consequently are thought of as subordinate factors (or dependent variables).

The accuracy of chemical test results is measured by establishing the average recovery. The recovery is determined by splitting a series of samples into two portions, spiking (adding a known quantity of the constituent of interest) one of the portions, and submitting both portions for laboratory analysis as independent samples. Recovery is expressed as a percentage.

To validate recovery data, the individual recoveries are compared with the average recovery value to identify individual values that lie outside the range of reasonableness. If outliers are identified, a new average recovery is recalculated using the remaining "good" values. The final average recovery value is used to eliminate any bias from the laboratory data.

The precision of the chemical test results is reflected in the amount of scatter that would be observed in repetitious measurements of a component in a single sample. In most sampling programs, scatter is attributable either to chemical analysis or to errors committed during sampling. Most of the time, sampling error will be small, and the principal source of scatter will be laboratory analysis.

All raw data collected from sampling and used in project reports will be appropriately identified and included in a separate appendix within the report. Data will be reported in units according to industry standards.

Reduction of laboratory measurements and laboratory reporting of analytical parameters will be in accordance with the procedures specified for each analytical method. Any deviations from the analytical method will be delineated in the QA/QC summary document. Analytical parameters will be reported in units generally accepted within the industry.

8.0 INTERNAL QUALITY CONTROL

Data quality and utility depend of many factors including: sampling procedures, sample preparation, analytical methods, quality control and documentation. The compiled data will be used to satisfy all defined criteria for evaluating potential risks and solutions, as well as for developing future study plans and sampling requirements. Different levels of data quality are needed for these various requirements.

Quality control procedures of the interpretive type (e.g. hydrogeological, geological, and geophysical data) cannot be subjected to the same precision and accuracy tests as can the laboratory data. Instead, these data will undergo engineering and scientific judgement review by the Chen-Northern review team.

9.0 PERFORMANCE AND SYSTEMS AUDITS

The Quality Assurance Manager, in conjunction with the AMRB and Site Project Managers, will develop and conduct external system audits. Performance audits will be conducted soon after each task is in operation, and repeated periodically as required by task needs and duration.

The Quality Assurance Manager will ensure that each laboratory QA officer has performed adequate internal audits of performance and systems prior to the submittal of QA reports to the Project Manager. The AMRB Project Manager will review work product quality to ensure that the project is performed in accordance with approved quality assurance procedures. In addition, individual task leaders will review work for technical accuracy and completeness.

10.0 PREVENTIVE MAINTENANCE

Preventive maintenance of field equipment will be performed in accordance with written procedures and requirements of the manufacturer or standard operating procedures developed for this project. A full complement of critical spare parts will be on-site during all field work. The Field Supervisor will be responsible for ensuring preventive maintenance procedures are implemented during the course of the project.

11.0 ROUTINE DATA ASSESSMENT PROCEDURES

Analytical data will be assessed by the Quality Assurance Manager as the data are received and following data validation. Assessment of analytical procedures not involving laboratory analyses will be completed by both the individual task leaders and the project manager. Quality assurance data will be assessed according to procedures discussed in Section 7.0. The AMRB Site Project Manager will be notified if any data does not meet the quality assurance objectives established for the project.

12.0 CORRECTIVE ACTIONS

Corrective action procedures which may be implemented as a result of audit findings or detection of unacceptable data will be developed on a case-by-case basis. Such actions may include altering procedures in the field, using a different batch of sample containers, or recommending an audit of laboratory procedures. The need for corrective action will be communicated to the AMRB Project Manager.

13.0 QA PROJECT REPORTS

All data package reports submitted to the Department of State Lands will include the results of the quality assurance workups and conclusions in a QA report. This report will be written by Chen-Northern's QA Coordinator and will summarize all data quality information. Final task or investigative reports will contain a separate QA section summarizing data quality information written by the QA Coordinator.

APPENDIX A

ANALYTICAL METHODS AND DETECTION LIMITS FOR INORGANIC ANALYSIS

TABLE 1
SOIL/MINEWASTE ANALYTICAL METHODS AND REQUIRED DETECTION LIMITS
Preliminary Assessment
Hughesville Mining District, Montana

Analayte(1)	Method(2)	Detection Limit (mg/kg)
Aluminum	EPA 6010	40
Arsenic	EPA 7060/7061	2
Cadmium	EPA 6010	1
Chromium	EPA 6010	2
Copper	EPA 6010	5
Iron	EPA 6010	20
Lead	EPA 6010	1
Manganese	EPA 7471	3
Mercury	EPA 6010	0.04
Nickel	EPA 6010	8
Silver	EPA 6010	2
Zinc	EPA 6010	4
Sulfur Fractionation	Modified Sobeck	---
Texture	ASA 43-5	---
pH	USDA 21A	---
Electrical Conductivity	USDA 4B	---

(1) All metals will be analyzed for both total and weak acid extractable.

(2) EPA, 1979 (revised 1983). Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, U.S. EPA, Cincinnati, Ohio.

American Society of Agronomy, 1965. Standard Methods of Soil Analysis. Monograph No. 9. C.A. Black, ed. Madison, Wisconsin.

USDA, 1969. Diagnosis and Improvement of Saline and Alkali Soils, Agricultural Handbook No. 60. L.A. Richards, ed. U.S. Government Printing Office, Washington D.C.

TABLE 2
SURFACE WATER AND GROUNDWATER ANALYTICAL METHODS AND REQUIRED DETECTION LIMITS
Preliminary Assessment
Hughesville Mining District, Montana

Analyte(1)	Method(2)	Detection Limit (μg/L)
Aluminum	200.7	200
Arsenic	206.2/206.3	1
Barium	200.7	200
Cadmium	213.2	0.2
Calcium	200.1	5,000
Chromium	215.2	10
Copper	200.7	25
Iron	200.7	100
Lead	239.2	1
Magnesium	200.7	5,000
Manganese	243.2	15
Mercury	245.1	0.2
Nickel	249.2	2
Potassium	200.7	5,000
Selenium	270.2/270.3	5
Silver	272.2	0.2
Sodium	200.7	5,000
Zinc	200.7	20
Alkalinity	310.1	5,000
Chloride	325.3	1,000
Fluoride	340.2	100
Nitrate + Nitrite	353.2	30
Sulfate	375.3	10,000
Specific Conductance	120.1	---
pH	150.1	---

(1) Surface water samples will be analyzed for both total and dissolved metal concentrations. Groundwater samples will be analyzed for dissolved metal concentrations only.

(2) EPA, 1979 (revised 1983). Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, U.S. EPA, Cincinnati, Ohio.